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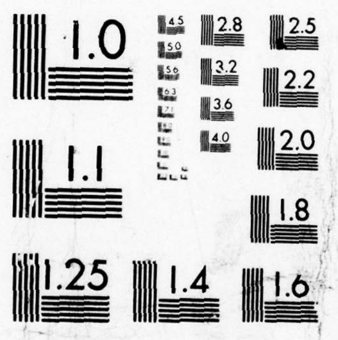

MICROCOPY RESOLUTION TEST CHART
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SVIC NOTES

Which Computer Program Should I Use?

The choice of the best general purpose finite element computer program by an organization is a difficult one for both analysts and their management, but recent efforts by the Interagency Software Evaluation Group (ISEG) should make the job easier. The difficulties and recent efforts at solving them are discussed below.

There are many reasons for not selecting a new program. An analyst will first try to solve a specific problem using personal knowledge, skills, and experience. If, for example, the analyst is an experienced NASTRAN user, the first thought is to use that program; it is the fastest, cheapest, and most reliable method. The problem is solved, and the analyst looks good to management. If it isn't possible to use NASTRAN, help from a knowledgeable close advisor or an expert outside the organization may be necessary, or it may be necessary to acquire a program, put it up, have the analyst learn to use it, and then solve the problem. Such a procedure is risky, costly, time consuming, and doesn't cast the analyst in a good light. The result of this selection process is that older programs become institutionalized, and few new programs are brought into the organization.

However, because of the many programs now available -- NASTRAN, ANSYS, DAISY, MARC-CDC, NISA, STARDYNE, STRUDL-II, ADINA, ASAS, BERSAFE, PAFEC, TITUS, ERUDYN, PAS, ISTRAN/S, SESAM-69, SAMBA, ASKA and COSA -- the selection process has become complex. First, it is difficult to obtain unbiased information about programs. Both program developers and experienced users tend to emphasize the positive qualities of a piece of software and deemphasize any negative aspects. Second, few helpful evaluations of programs have been produced.

In recognition of these problems the ISEG was formed. The group has initiated an effort to critically evaluate applications computer programs [1, 2]. The group is composed of various research and development agencies of the U.S. government. Army, Navy, Air Force, National Science Foundation, Department of Energy, and Nuclear Regulatory Commission. Members of the ISEG have developed selection and screening criteria for both software and evaluators. Fairly detailed evaluation criteria have been established, and an initial set of codes has been chosen for evaluation. NASTRAN, ADINA, STAGS, SAP, and a family of shell-of-revolution codes have been selected for study. The documentation of these efforts will be similar to a consumer report on software. Such reports will guide the potential user to the best particular code and take a lot of the guesswork out of the selection process.

As more and more governmental agencies require newer software, the documentation efforts will result in cost-effective use of available software resources. The U.S. government is one of the biggest users of applications software and will benefit most by funding these efforts. It is hoped that each governmental agency will continue this worthwhile effort by becoming active members and supporters of the ISEG. It is a cooperative effort, with each member getting as much out as they contribute.

J.G.S.

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EDITORS RATTLE SPACE

TECHNICAL INNOVATION

The topic of technical innovations was explored recently in an article* by Dr. Robert C. Dean, Jr. This article explored in detail the fact that American engineers, among others, have been the cause of the technical and industrial decline that has led to a loss in productivity. During the period of this decline of innovation in U.S., such countries as Germany and Japan have moved ahead.

Dean makes the following interesting observations about innovation and wealth.

> **Innovation is a fundamental premise for our social comfort and economic prosperity. It is one of the primary sources of our wealth. The author (Dean) has reached the conclusion that there are only two major sources of wealth. One comes from natural resources. Obviously, the oil-rich countries are enjoying a generation of booming bonanza by selling off their natural resources. But natural resources are a temporal and limited source of wealth. The only permanent wellsprings of wealth that I can identify are those that are associated with the human intangibles, namely, skill, ingenuity, drive, perseverance, and faith.**
>
> **Capital alone cannot create real wealth. Numerous economic studies have shown that the growth of an economy (as expressed by the gross national product) and the increase in productivity are most strongly correlated with a nation's innovative capabilities. Historically, this has always been the strong suit of the U.S. and it has been responsible for fueling our expanding economy ever since the earliest days of the republic.**

If this is the case, why has innovation reached a plateau? Dean suggests that we have become a "cautious, demanding-our-return-now, low-risk society," Studies show that corporations have become cautious and therefore have reduced their R&D budgets. Of course, technology is developed as a result of R&D.

On the other hand, individual entrepreneurs have not been as active as in past years. Perhaps this means that the affluent society of today is not interested in the hard work, sacrifice, and risk involved in entrepreneurship.

What will happen if this trend continues? In all probability the lower standard of living will be lower for all of us. Innovation is the seed from which increased productivity germinates. And without increased productivity we must accept the inflation that will result in a lower standard of living.

R.L.E.

***Dean, Robert C., Jr., "Technical Innovation USA," Mech. Engr., pp 20-32 (Nov 1978).**

DYNAMIC SNAP-THROUGH OF SHALLOW ARCHES AND SPHERICAL CAPS

S.M. Holzer*

***Abstract** - This article reviews the current literature on effects of asymmetric perturbation and the spatial distribution of the load on dynamic snap-through of shallow arches and spherical caps.*

A survey of publications between 1976 and 1978 on dynamic snap-through of shallow arches and spherical caps indicates that the investigations have been primarily concerned with the effects of asymmetric motion and the spatial distribution of the load on dynamic snap-through. Those efforts are addressed in this review. A related literature survey has been presented [1].

ASYMMETRIC PERTURBATION

The studies of asymmetric dynamic snap-through induced by symmetric loads are based on two methods. In one method conditions are sought that give rise to parametric excitation of the asymmetric motion. The corresponding value of the load -- the threshold value at which the asymmetric response shows significant growth rate -- has been defined in some studies as the asymmetric dynamic snap-through load [2, 3]. In the second method the Budiansky-Roth criterion [4] is used to predict asymmetric dynamic snap-through from the nonlinear motion. Asymmetric components of the motion are excited through imperfections in the symmetric load distribution [5, 6, 7], geometric imperfections [8], and small numerical roundoff errors [2].

Parametric Excitation

Lock's paper [9] has been the key reference in many studies on parametrically induced snap-through; a brief summary of his work is therefore pertinent. Lock investigated the dynamic snap-through of a shallow sinusoidal arch subjected to symmetric step pressure loading over a range of arch geometries. He identified two distinct mechanisms for initiating the snapping process; they are referred to as direct and indirect (parametrically induced) snapping. Direct snapping means that the symmetric component of the motion grows immediately upon application of the load, and the arch snaps through. This behavior is characteristic for low values of the shallowness parameter. Indirect snapping was observed for higher values of the shallowness parameter. In this geometric range, the symmetric motion can parametrically excite the asymmetric component of the response, which in turn can interact with the symmetric component to initiate snapping. Accordingly, the problem of indirect snapping can be viewed in the sense of Liapunov as the stability of the symmetric motion relative to asymmetric perturbations. This approach was taken by Lock [9], who reduced the problem of dynamic stability of the symmetric motion (approximately) to the Mathieu equation for which regions of stability and instability could be established in the load-shallowness parameter plane. However, these results represent only conditions of infinitesimal stability or instability of the symmetric motion. Thus, it remained to be determined whether the initiation of parametric excitation of the asymmetric response in an infinitesimal neighborhood of the symmetric motion could lead to finite motions and dynamic snap-through. To resolve this question, Lock integrated the nonlinear equations of motion numerically and applied the Budiansky-Roth criterion to determine dynamic snap-through pressures. He found that the dynamic snap-through pressures predicted by the nonlinear analysis are always higher than the pressures predicted by the infinitesimal stability analysis to initiate parametric excitation of the asymmetric motion; i.e., the dynamic snap-through pressures are always contained within the regions of parametric resonance. Moreover, for high values of the shallowness parameter the two predictions are quite close. Lock concluded that "the conditions associated with this resonance phenomenon must play an important part in the indirect snapping problem" [9].

Lo and Masur [11] investigated the dynamic snap-through of a shallow circular arch. In a manner analogous to that of Lock [9], they reduced the problem of the infinitesimal stability of the symmetric motion relative to asymmetric perturbations (approximately) to the Mathieu equation. The

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conditions of parametric resonance were considered as measures of dynamic imperfection-sensitivity of the arch.

Akkas [3] investigated the asymmetric dynamic behavior of shallow spherical shells under uniform step pressure loading. As proposed by Fulton and Barton [2], the asymmetric dynamic snap-through load was defined as the threshold value of the pressure at which the asymmetric response shows significant growth rate. In order to determine the threshold pressure, the asymmetric dynamic perturbation equations were expressed in a form similar to Hill's equation. However, the reduction of this equation to the Mathieu equation was not apparent, and numerical solution techniques were employed. A comparison of the critical pressures with those of previous numerical and experimental investigations [5, 6, 12] was presented. A brief survey of asymmetric dynamic stability investigations of cylindrical shells was also given [3].

Svalbonas and Kalnins [7] compared and evaluated various methods and computer programs used in the dynamic buckling analyses of shells. A shallow spherical cap subjected to uniform step pressure loading was selected as a test problem. The predictions of asymmetric dynamic buckling of this shell by various methods were investigated and compared. In particular, the program KSHEL (spatial integration, modal superposition, perturbation approach) was used to determine conditions of parametric resonance for arbitrary asymmetric perturbations. The critical pressures predicted by KSHEL were high upper bounds to dynamic snap-through pressures and were considered to be unacceptable. It was reasoned that the approximations introduced to reduce the governing equations to the Mathieu equation were not justified for this problem. Potential cures for this approach, which is efficient, are being tested.

Dynamic Snap-Through

Most methods of predicting dynamic snap-through from the characteristics of the nonlinear motion are based on the observation by Budiansky and Roth [4] that in the vicinity of a certain pressure, which is defined as the critical pressure, a sudden increase in the deformation of the shell takes place. The actual determination of the critical pressure is based on a plot representing the relation between the peak value of some measure of response and the amplitude of the applied load. Among the measures of response selected are average displacement parameters [11], volume change parameters [6, 7, 13, 14], and vector norms of generalized displacements [15]. If the peak response-load curve exhibits a distinct jump, the critical pressure is well defined. In some cases, however, the transition from the prebuckling to the postbuckling pressure is gradual. In others the peak response-load curve even exhibits an oscillatory character [6, 7, 15]; this suggests that, for a given value of a pressure causing snap-through, a higher value can be found that does not. To aid in the selection of critical pressures under such conditions, various guidelines have been employed. For instance, the point of inflection or the knee of the curve below the point of inflection has been chosen to define the critical pressure [7, 13-15].

Asymmetric dynamic snap-through of shallow spherical shells under uniform step pressure loadings has been investigated [7, 16]. In one case [7] critical pressures were obtained via the computer programs DYNASOR (finite elements, time integration of nonlinear dynamic equilibrium equations), SATANS (finite differences, pseudo load method, time integration), and STARS-2D (spatial and time integration, nonlinear equilibrium or perturbation approaches). The critical pressures were compared to each other and to those presented elsewhere [5, 6, 17, 18]. Comparisons were made on the basis of accuracy, idealization complexity, ease of use, user expertise, and experience required for analysis. One computer program [16] can be characterized as a finite element, mode superposition, time integration program. Critical loads were obtained for step loadings composed of a uniform pressure and a concentrated load applied at the apex of the shell. These results were compared with others [5, 12].

The asymmetric dynamic snap-through of a shallow dome support consisting of two perpendicular circular arches subjected to uniform pressure loading has been investigated [8]. Geometric imperfections affected the snap-through of one of the two configurations analyzed.

SPATIAL LOAD DISTRIBUTION

The studies of the effect of the spatial distribution

of the load on dynamic snap-through [15, 19, 20] utilized, in addition to motion criteria [1] -- e.g., the Budiansky-Roth criterion -- an energy criterion, which represents a sufficient condition of dynamic stability. This criterion, proposed by Hsu [21], was shown to follow directly from a theorem on extent of asymptotic stability of Liapunov's direct method [22]. In essence, the sufficient condition states that a specific transient load will not cause dynamic snap-through if the resulting motion initiates in the domain of attraction of the equilibrium state and if the total energy along this motion does not reach the value M during the time of excitation. M is the change in the potential energy between the stable equilibrium state, whose dynamic stability is in question, and the nearest unstable equilibrium state [22]. The sufficient condition can also be used if the dynamic load consists of a step load of infinite duration [23].

An unloaded shallow circular arch has been subjected to impulsive loads with various spatial distributions [15]. Critical loads were determined on the basis of the Budiansky-Roth criterion and compared with lower bounds established via Hsu's sufficiency condition. Analogous to Lock [9], two mechanisms of dynamic snap-through were identified; they are called immediate and finite time snap-through. The study showed that the critical impulse is sensitive to the spatial distribution and that for most distributions the sufficiency condition is considerably less conservative for finite time snap-through than for immediate snap-through. However, these results do not reflect the effect of damping.

The dynamic stability of reticulated domes has been investigated for various static and dynamic (impulsive and transient) load combinations [19, 20]. Specifically, the hypothesis tested is that, for each static load configuration of the equilibrium state, there exists a dynamic load for which the sufficient condition of dynamic stability is also a necessary condition. Dynamic snap-through is decided on the basis of the phase portraits of the individual generalized displacements. The test results so far support this hypothesis.

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ERRATA

Dynamic Stability of Elastic Imperfection-Sensitive Shells
Volume 8, No. 4: April 1976

The following corrections apply to page 4.

Equation (1): $\dot{y} = f(y)$

Paragraph 2: y_o, and the corresponding solution is denoted $y(t, y_o)$.

Equation (5): $\|y_o\| < \delta_o$

LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains review articles on finite element-related techniques as applied to acoustic propagation in the ocean and stability problems in rotor systems.

Dr. Kalinowski of the Naval Underwater Systems Center, New London, has written a two part review article on acoustic propagation in the ocean. Part 1 describes the application of the finite element method to ocean problems including modeling and simulation of boundary conditions.

Dr. Iwatsubo of Kobe University describes self-excited lateral vibrations that cause instabilities in rotating machinery.

A SURVEY OF FINITE ELEMENT-RELATED TECHNIQUES AS APPLIED TO ACOUSTIC PROPAGATION IN THE OCEAN PART I: FINITE ELEMENT METHOD AND RELATED TECHNIQUES

A.J. Kalinowski*

***Abstract** - This two part article deals with finite element-related techniques applied to acoustic propagation in the ocean. Methods for modeling and simulation of boundary conditions are discussed including the related Boundary Solution Method and the Boundary Integral Method in Part 1 and transparent boundary simulation techniques in Part 2.*

The propagation of acoustic energy in the ocean is a broad subject involving fluid-solid interaction effects in a fluid domain bounded by a free surface from above and by some kind of geological solid media from below. Solutions for such pertinent response variables as fluid pressure and solid media stresses (and deformations) require simultaneous solutions to partial differential equations governing both fluid and solid media; coupling of the response variables takes place across the fluid-solid interface. The finite element method (FEM) as it exists today was initially developed [7] in structural mechanics by the aircraft industry. A complete history is available [14]. Generalization of the technique soon followed [9], and the FEM has had many nonstructural applications -- fluid mechanics, acoustics, electro-magnetic field theory, and heat transfer. In fact finite element conferences have been held for nonstructural applications [10]. The method is thus well documented, and a large number of books have been published, including introductory texts [1, 16, 21, 22], theoretical books [13, 15], and a collection of more than 7,000 references [17].

The propagation of acoustic energy in the ocean involves the interaction between acoustic wave propagation in fluids and stress wave propagation in solids. Much finite element-related work is available in fluids, either fluids alone or interacting with submerged structures [5, 6, 10-12], and in solids, either solids alone or interacting with buried structures [2-4, 23-27, 46]. Very little finite element work pertaining to acoustic wave propagation has been published in which the ocean bottom is treated as a coupled part of the solution; that is, the model of the bottom is more detailed than is implied by the usual approach of either a rigid or known prescribed impedance-type boundary condition.

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Only the finite element-related references were found that directly address the class of problems considered in this survey [18, 28]. In one finite element scheme suggested for acoustic propagation problems [28], modeling of both the fluid domain and irregularly shaped multilayered bottom with rotationally symmetric ring elements or planar elements was considered. The solution technique has a sound speed profile in which variation with both range and depth is permitted. The technique also has the following features: the shape of neither the ocean surface nor the ocean bottom need be flat; both dilatational and shear waves are permitted in the ocean floor model; a dissipative loss factor associated with the bottom physical properties can be implemented in the solution; the fluid domain need not be simply connected, i.e., voids in the fluid domain, a school of fish for example, can be accounted for in the model; the ring element formulation allows three-dimensional directional sources to be modeled via a Fourier expansion of the field solution in angular harmonics; and the method is immediately adaptable to existing general purpose programs such as NASTRAN [29]. A demonstration solution using the same method is given later in this survey.

A Galerkin-type variational scheme that eventually leads to a finite element formulation has been reported [18] although it is not specifically identified as such. The fluid domain is treated as rotationally symmetric, and is bounded by a flat free surface and by an arbitrary shaped (but rigid) bottom. Further, sound speed properties are permitted to vary both in depth and range. An accurate procedure for handling the infinite domain boundary condition -- i.e., transparent boundary -- at the truncation end of the finite element mesh is included. Although the method [18] works in theory for variable sound speed conditions, the numerical examples were for

homogeneous fluid media, bounded by a flat free surface and by a rigid, sinusoidal shaped bottom in one case; in another case a flat rigid bottom was treated.

THE FINITE ELEMENT AND RELATED METHODS

The finite element method (FEM) has become firmly established over the past 20 years.[1] Two closely related numerical techniques, the boundary solution method (BSM) and the boundary integral method (BIM) are often used in conjunction with the FEM [8]; i.e., part of the field is solved with finite elements, and the remainder is treated with one of the other techniques. The advantage of combining the techniques is that usual problems associated with attempting to model a media domain that extends to infinity are avoided; the BSM and BIM treat the infinite domain truncation.

Finite Element Method

Consider the case in which the response of a continuum is expressed by the solution to the partial differential equation(s)

$$[A(\phi)] = 0 \tag{1}$$

This solution applies to a domain Ω in which boundary conditions

$$[B(\phi)] = 0 \tag{2}$$

are satisfied on the boundary Γ; [A] and [B] are general partial differential operators, and $\{\phi\}$ are function(s) representing the continuous field solution.[2] The quantity $[B(\phi)]$ is often defined as a mixed boundary value problem; i.e., $[B] = [B_1(\phi)]$ on Γ_1 and $[B] = [B_2(\phi)]$ on Γ_2 where $\Gamma = \Gamma_1 + \Gamma_2$.

The unknown response function(s) $\{\phi\}$ is approximated by a series of prescribed shape functions $[N(\bar{x})]$ and associated unknown multiplying factors $\{a\}$

$$\{\phi(\bar{x})\} \approx \{\hat{\phi}(\bar{x})\} = [N(\bar{x})]\,\{a\} \tag{3}$$

The column vector $\{a\}$ has components, $[a_1, a_2, \ldots a_I]^T$.

The unknowns are represented by discrete $\{a\}$ values rather than the continuous $\{\phi(\bar{x})\}$ function. The $\{a\}$ values are determined as solutions to a set of approximating equations with such integral forms as

$$F_j(a_i) \equiv \int_\Omega G_j(\hat{\phi})d\Omega + \int_\Gamma g_j(\hat{\phi})d\Gamma = 0 \quad j=1,2,\ldots I \tag{4}$$

The form of $F(a_i)$ can be obtained by various formulations. The domain Ω and boundary Γ are subdivided into K finite element zones (Figure 1) in which Ω_k^e, Γ_k^e denote the domain and boundary of a typical kth element; the integrals appearing in equation (4) are thus composed of the sum of the K element contributions.

$$\int_\Omega G_j(\hat{\phi})d\Omega = \sum_{k=1}^{K} \int_{\Omega_k^e} G_j(\hat{\phi})d\Omega \tag{4a}$$

$$\int_\Gamma g_j(\hat{\phi})d\Gamma = \sum_{k=1}^{K} \int_{\Gamma_k^e} g_j(\hat{\phi})d\Gamma \tag{4b}$$

The Σ operators refer to the standard assembly rules of structural forms [1, 22].

The usual condition, although not an absolutely necessary one, is that the trial shape functions $N_i(\bar{x})$ be narrowly based; i.e., for an arbitrary unknown i, $N_i(\bar{x})$ are given zero values everywhere except in elements containing the unknown a_i. These trial functions lead to a set of banded (often symmetric) set of simultaneous equations for the unknowns $\{a\}$.

Substitution of the shape function expansions given by equation (3) into equation (4) and completion of the explicit spacial integrations, numerically if necessary, yield a set of simultaneous equations for the unknowns $\{a\}$. The narrowly based trial shape functions affect only the bandedness of the resulting set of simultaneous equations; they are not a strict requirement of the FEM technique [30]. The various finite element approaches differ in the choice of prescribed shape functions $N(\bar{x})_i$ and also in the manner in which the approximating equations -- equations (4), (4a), and (4b) -- are derived. Specific integral formulations of equation (4) are constructed either from weak formulations of the Galerkin, least square, or collocation methods or by introducing the popular but not always applicable

1. Concise descriptions of the FEM, BSM, and BIM have been published [8] for a general class of field solutions. The development of these methods has been condensed in this section, and slightly different notation is used. Reference [8] is interpreted herein with emphasis placed on aspects of these methods relevant to the ocean-bottom interaction problem.

2. The standard [ ], { } notation for matrices and column vectors respectively are used in the finite element section.

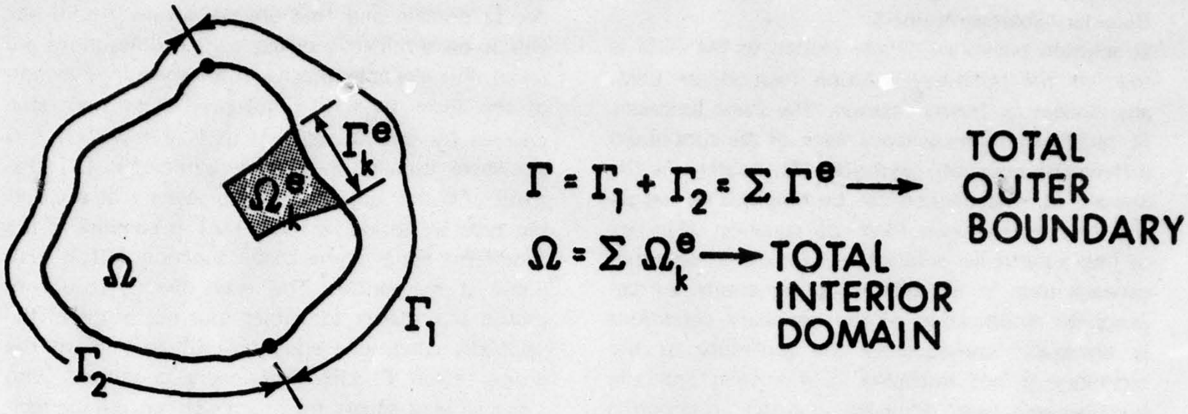

Figure 1. Definition of Interior Domain Ω and Boundary Γ

variational principles. In the least square and variational principle formulations, the development of the $F_j(a_i)$ in equation (4) involves minimization of the functional $I(\hat{\phi})$

$$F_j(a_i) = \frac{\partial I(\hat{\phi})}{\partial a_j} = 0 \quad j = 1, 2, \ldots I \tag{5}$$

over the problem variables $\{a\}$, where $I(\hat{\phi})$ is of the form

$$I(\hat{\phi}) = \int_{\Omega} H(\hat{\phi})\,d\Omega + \int_{\Gamma} h(\hat{\phi})\,d\Gamma \tag{6}$$

The evaluation of the $F_j(a_i)$ expression in equation (5) usually leads to a set of linear algebraic equations of the form[3]

$$[K]\{a\} = \{f\} \tag{7}$$

For either the variational principle or the least square formulation, it follows from equation (5) that the $G_j(\hat{\phi})$ and $g_j(\hat{\phi})$ are related to $H(\hat{\phi})$ and $h(\hat{\phi})$ by

$$G_j(\hat{\phi}) = \frac{\partial H(\hat{\phi})}{\partial a_j}\ ; \ g_j(\hat{\phi}) = \frac{\partial h(\hat{\phi})}{\partial a_j}$$

The matrix $[K]$, known as the generalized stiffness matrix of the system in structural applications, is obtained from the volume integrals of equation (4), and the problem loading $\{f\}$ is determined from the surface integrals of equation (4). From a computational viewpoint, it is desirable to have the resulting $[K]$ banded and symmetric, although not all FEM formulations have this feature.

The volume integration in equation (4) leads to the generalized stiffness matrix $[K]$. Attention is thus focused on the various forms of the kernel $H(\hat{\phi})$ employed for a specific problem; namely, solving for the steady state acoustic response in a fluid domain governed by the Helmholtz equation

$$\nabla^2\phi(\bar{x}) + k^2\phi(\bar{x}) = 0 \tag{8}$$

The fluid pressure p is related to the velocity potential by the relation $\phi = i\omega\rho p$, with ρ = fluid density, $k = \omega/c$, ω = frequency, and c = a piecewise constant (within an element Ω_k^e) sound speed.

$$G_j(\hat{\phi}) = \frac{\partial H(\hat{\phi})}{\partial a_j} = \frac{\partial}{\partial a_j}\left(\nabla\hat{\phi} - \nabla\hat{\phi} - k^2\hat{\phi}^2\right) \tag{9a}$$

Equation (9a) leads to equation (7). Another approach [18] employs a Galerkin variational form.

$$G_j(\hat{\phi}) = -\nabla\hat{\phi}\cdot\nabla\psi_j + k^2\hat{\phi}\psi_j \tag{9b}$$

The weight function $\psi_j(\bar{x})$ has the form of the shape functions $N_j(\bar{x})$ and leads to an alternate form of equation (7).

A least square approach has been used [31]

$$G_j(\phi) = \frac{\partial H(\hat{\phi})}{\partial a_j} = \frac{\partial}{\partial a_j}\left(\nabla^2\hat{\phi} + k^2\hat{\phi}\right)^2 \tag{9c}$$

It leads to still another form of equation (7).

3. In such cases as transient solutions [1], or with special single continuous co-ordinate finite element formulations [38], equation (7) could be an ordinary differential equation in $\{a\}$.

Boundary Solution Method

A solution technique closely related to the FEM is that of the boundary solution method, or BSM, also known as Trefftz method. The shape functions N_i satisfy the homogeneous form of the continuum differential equation, equation (1), exactly in the domain Ω. The method can be modified to handle the nonhomogeneous form of equation (1); i.e., to find a particular solution to handle the nonhomogeneous term in the differential equations. An appropriate modification of the boundary conditions is necessary; consequently the generality of the technique is not restricted in discussing only the homogeneous case. A mixed boundary condition is treated, equation (2) is then rewritten.

$$\begin{aligned} \{\phi\} - \{\overline{\phi}\} &= 0 \text{ on } \Gamma_1 \\ \{q\} - \{\overline{q}\} &= 0 \text{ on } \Gamma_2 \end{aligned} \tag{10}$$

The barred quantities are the prescribed values on the surface; $\{q\}$ is a natural conjugate variable and is related to $\{\phi\}$ by

$$\{q\} = [P]\{\phi\} \tag{11}$$

$[P]$ is a differential operator -- e.g., in the previous acoustic example defined by equation (8), $\mathbf{P} = \partial(\ )/\partial n$. Thus $\{q\}$ represents the velocity normal to the surface.

The shape functions satisfy equation (1) exactly; i.e., $[A([N]\cdot\{a\})] = 0$. The $\{a\}$ values that satisfy the boundary conditions, equation (10), remain to be determined. This is accomplished by multiplying parts of equation (10) by a selected weighting function $\{W_j(\overline{x})\}$ and integrating over the surface.

$$\begin{aligned} \int_{\Gamma_1}\{W_j\}^T(\{\hat{\phi}\} - \{\phi\})d\Gamma &\equiv \int_{\Gamma_1}\{W_j\}^T(\sum_1^I[N]\{a\} - \{\overline{\phi}\})d\Gamma = 0 \qquad j = 1, 2, \ldots m \\ \int_{\Gamma_2}\{W_j\}^T(\{\hat{q}\} - \{q\})d\Gamma &\equiv \int_{\Gamma_2}\{W_j\}^T(\sum_1^I[P][N]\{a\} - \{\overline{q}\})d\Gamma = 0 \qquad j = m+1, m+2, \ldots I \end{aligned} \tag{12}$$

A balanced set of equations and unknowns expressible in the form of equation (7) result. Unlike the basic FEM discussed earlier, the [K] matrix will not be banded (because the shape functions span the Ω domain and thus are not locally based) nor will it be symmetric unless certain precautions are taken. For example, a collocation weighting function of the form $[W_j(\overline{x})] = 1.0$ over the surface area covered by the jth segment of Γ and $[W_j(\overline{x})] = 0$ elsewhere usually leads to nonsymmetric [K] matrices. Another approach [8] suggests that a Galerkin type weighting be used; $[W_j]$ is equated to the functional form if the shape function [N] is evaluated at the surface. This leads directly to a symmetric [K] matrix for either (but not both) of the boundary conditions, equation (10), applied over the entire region Γ. Mixed boundary conditions with a special least square treatment [8] can also indirectly lead to symmetric [K] matrices.

Boundary Integral Method

The boundary integral method (BIM) is useful in treating domains that extend to infinity. Suppose the solution[4] $\phi(x)$ can be expressed in integral form

$$\phi(\overline{x}) = \int_\Gamma G_1(\overline{x},\overline{z})\phi(\overline{z})d\overline{z} + \int_\Gamma G_2(\overline{x},\overline{z})\mathbf{P}\phi(\overline{z})d\overline{z} \tag{13}$$

G_1 and G_2 are singularity functions and are usually a consequence of Green's identity; $\mathbf{P}$ is the differential operator defined in equation (11).

Equation (13) is discretized, assuming

$$\begin{aligned} \phi(\overline{x}) &= \{M^b(\overline{x})\}^T\{b\} \\ \mathbf{P}\phi(\overline{x}) &= \{M^a(\overline{x})\}^T\{a\} \end{aligned} \tag{14}$$

where $\{M^b(\overline{x})\}$, $\{M^a(\overline{x})\}$ are interpolating functions for evaluating ϕ or $\mathbf{P}\phi$ on the surface. If the domain Γ interfaces with a surface made up of finite elements, such as that encountered in a mixed FEM-surface integral approach, the finite element shape functions can be used for $\{M^b\}$ at the interface. Equation (14) is substituted into equation (13); upon evaluation of the resulting expression by collocation over a discrete set of $\overline{x}_i$ surface points, a linear set of equations is obtained of the form

$$[\tilde{A}]\{a\} = [\tilde{B}]\{b\} \tag{15}$$

These equations are the desired form, relating surface unknowns $\{a\}$ and $\{b\}$. For example, if $\mathbf{P}\phi(\overline{x})$, or equivalently $\{b\}$, is specified on Γ, equation (15) can be used to solve for $\{a\} = [\tilde{A}]^{-1}[\tilde{B}]\{b\}$. A specific example of the G_1 and G_2 expressions of

4. A single vector ϕ is taken as the unknown; however, the BIM is not limited to this situation.

equation (13) is given for the acoustic case (equation (8) holds in Ω); [33], G_2 and G are related to the free space, Green's function [33].

$$G(\bar{x},\bar{y}) = \frac{\exp(-i\omega|\bar{x}-\bar{y}|/c)}{4\pi|\bar{x}-\bar{y}|}$$

where $G_1 = -2\partial G/\partial n(\bar{y})$; $G_2 = -2G$; and $\bar{y}$ is a dummy integration variable as on the surface domain Γ. In fact expressing G_1 and G_2 in this manner infers that equation (13) is the Helmholtz integral equation for this particular case.

Features of the Methods

Numerical solutions employing each of the methods described have certain advantages and disadvantages. The list in reference [8] is adapted for ocean applications.

With the FEM:

- Both the ocean (fluid) and bottom (solid) are easily represented with finite elements. Because the total fluid and bottom domain are modeled with individual finite elements, each with its own set of physical constants, the following can be represented: solid media with multi-material properties (e.g., layers); and a fluid with a variable sound speed profile in one, two, or three directions. Further, the boundaries of the media can be irregular, so that sea mounds, for example, can be included in the model.

- Nonlinearities can be included in the formulation -- e.g., a nonlinear representation of the bottom media stress-strain law. This is accomplished at the expense of treating the time variation as a transient, rather than a steady-state, problem, however.

- Due to the locally based shape functions, the final equations for the discretized unknowns are banded (and usually symmetric), thus offering certain computational advantages with relation to speed of solution and computer storage capacity.

- The unknown parameters $\{a\}$ are physically identifiable; e.g., displacement and pressure variables for the ocean-bottom interaction problems.

- The number of unknown parameters $\{a\}$ is large in that both the volume domain Ω and surface domain Γ are discretized; this is a disadvantage for ocean problems, especially if a total three-dimensional representation is considered. Practically, two-dimensional planar or rotationally symmetric domains are considered to maintain a manageable number of degrees of freedom; theoretically, however, the method is entirely applicable to the general three-dimensional case.

- Representation of the infinite domain presents a problem where only approximate truncation boundary conditions are normally employed.

- For steady-state problems, as many as eight elements per wave length could be required to adequately model the domain [3, 35]; however, the methodology of reference [18] appears to require less fine modeling with their particular approach (e.g., two elements per wavelength).

- Singularities that arise under concentrated loads are troublesome to model; e.g., the representation of a point (or line) source radiating from some location in the ocean as treated in reference [28].

With the BSM:

- Exact solutions, except for unknown constant coefficients, are required as shape functions in the entire problem domain; thus, the successful application to variable sound speed fluid media (or when combining fluid-bottom domain problems) is doubtful except for simple situations in which the media is homogeneous and linear.

- The number of unknowns is smaller than with the FEM for the same size domain Ω; however, a computationally desirable banded (and possibly symmetric) generalized [K] matrix is not usually realized.

- Physical identification of the parameters is not usually possible; e.g., the unknowns are coefficients of a solution expansion of some kind.

- Infinite (or semi-infinite) domains and singularity loadings are readily treated; this is of particular importance in the ocean-bottom interaction

problem.

With the BIM:

- The boundary integration techniques are usually limited to homogeneous media because of the unavailability of the integral equation formulations for the more complicated nonhomogeneous media involving variable sound speeds. This is a disadvantage relative to the ocean-bottom interaction problem; however, the BIM still could be of use in a mixed formulation as explained in Part 2 of this survey.

- Even if the media were homogeneous, proper treatment of portions of the boundary -- the ocean bottom or its surface -- that extends to infinity could create numerical difficulties.

- The number of unknown parameters is related to the number of surface point discretizations.

- The linear discrete equations, equation (15), involve inversion of matrices that are not banded nor symmetric. Solutions to large, complex, matrices are often difficult; the final results are not necessarily numerically accurate, and unreasonably long computer run times are typical.

- Application of the BIM often involves subtle numerical difficulties; in particular, the cavity resonance condition [34, 55], in which steady-state driving frequencies ω are at or close to certain characteristic wave numbers of the fluid domain.

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STABILITY PROBLEMS ON ROTOR SYSTEMS

T. Iwatsubo*

***Abstract** - This survey is concerned with self-excited lateral vibrations that cause instability of rotating machinery. Instability phenomena are described and classified.*

This article reviews self-excited lateral vibrations that cause rotating machinery to become unstable. The following causes of instability are described; internal damping, dry friction, journal bearing (oil whip), fluid forces, ball bearings, universal joint, and asymmetric factors.

Instability due to Internal Damping

Rotor whirling due to internal friction was first experimentally found by Newkirk [1]. This phenomenon was explained by Kimball [2]. It is now generally treated in standard texts [3-5].

Assume that a rotor consists of a disk of mass m and a massless shaft with a spring constant k. The rotor is supported by rigid bearings; internal damping c_i exists in the rotating shaft and external damping c_e in the system. The equations of motion of the system

$$\begin{cases} m\dfrac{d^2u}{dt^2} + C_e\dfrac{du}{dt} + C_i(\dfrac{du}{dt} + \omega v) + ku = f_u(t) \\ m\dfrac{d^2v}{dt^2} + C_e\dfrac{dv}{dt} + C_i(\dfrac{dv}{dt} - \omega u) + kv = f_v(t) \end{cases} \tag{1}$$

where ω is the angular velocity of the rotor. Equation (1) can be written in complex form by setting $Z = u + iv$ $(i = -1)$

$$\frac{d^2Z}{dt^2} + \underbrace{d_e\frac{dZ}{dt}}_{\substack{\text{external}\\ \text{damping force}}} + \underbrace{d_i(\frac{dZ}{dt} - i\omega Z)}_{\substack{\text{internal damping}\\ \text{force}}} + \Omega_o^2 Z = F(t) \tag{2}$$

where $d_e = \dfrac{c_e}{m}$, $d_i = \dfrac{c_i}{m}$, $\Omega_o^2 = \dfrac{k}{m}$.

The solution of equation (2) can be written in the form

$$Z = Ae^{i\lambda t} \tag{3}$$

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Substitute the expression of equation (3) into equation (2).

$$\begin{cases} \lambda = \Omega_o \\ \omega = \Omega_o(\dfrac{d_i + d_e}{d_i}) \end{cases} \tag{4}$$

The first equation means that the vibration mode at the boundary of instability region is Ω_o; the second equation represents the boundary between stability and instability.

The character of internal damping by substituting equation (3) into equation (2).

$$F_i = id_i(\lambda - \omega)Ae^{i\lambda t}$$

Because $\lambda = \Omega_o$, the sign of the internal damping force changes at the rotating speed $\omega = \Omega_o$. If $\omega < \Omega_o$, positive damping occurs; if $\omega > \Omega_o$, damping is negative.

This phenomenon, which has been clearly explained [3-6], is summarized in Figure 1. The direction of the internal damping force is as same as that of the external force below the critical speed; above critical speed, the directions are opposite.

Much work on instability due to internal damping has been published, including stability of rotor systems with internal and external dampings [7-9], stability of rotors with internal and external damping and supported by asymmetric stiffness bearings [10, 11], stability of a continuous rotor system with internal and external damping [13, 14], and influence of nonlinear internal damping force on the stability of a rotor system [15]. A discussion of experimental and theoretical results is available [12].

Instability due to Dry Friction

Instability due to dry friction has been explained [6]; it is shown in Figure 2. When radial contact is made between the surface of a rotating shaft and some static region, Coulomb friction induces a tangential force on the rotor. Because the friction

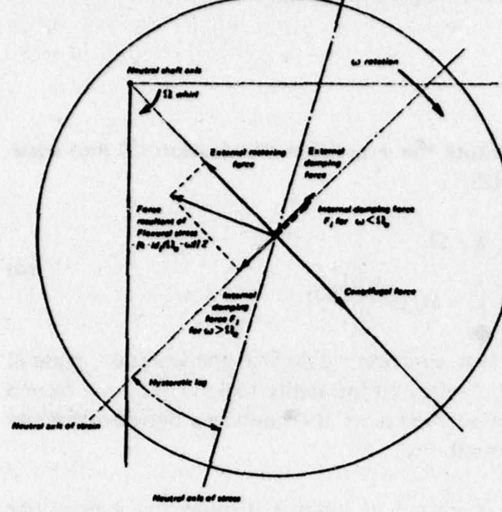

Figure 1. Instability due to Internal Damping

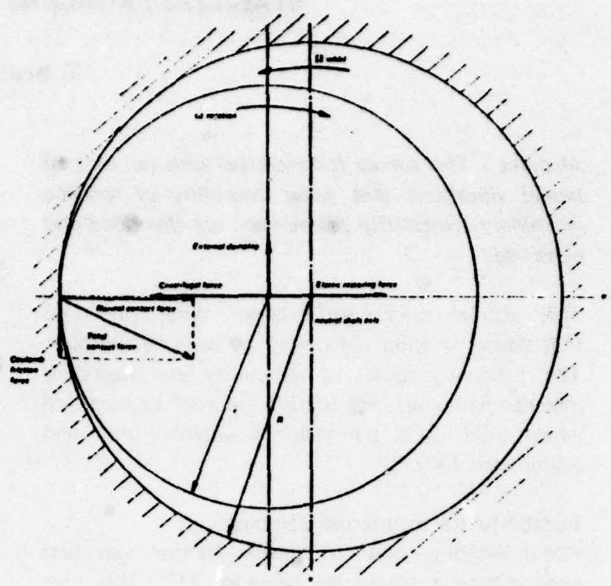

Figure 2. Instability due to Dry Friction

force is approximately proportional to the radial component of the contact force, conditions for instability exist. The tangential force induces a whirling motion that increases the centrifugal force on the rotor. This force in turn leads to a large radial contact and hence an increase in the whirl-inducing friction force.

The rolling contact between the shaft surface and the static region is shown in equation (6).

$$\omega_o = \left(\frac{R-r}{r}\right)(-\Omega_o) \quad (\omega_o > 0, \Omega_o < 0) \tag{6}$$

where r and R are the radius of the shaft and the static surface respectively, and ω_o and Ω_o are the rotating speed and the whirling speed of the rotor respectively.

This whirl occurs only under the condition shown below.

$$\omega > \left(\frac{R-r}{r}\right)(-\Omega) \quad (\Omega < 0) \tag{7}$$

As (R − r) is very small, instability due to dry friction occurs at slow rotating speeds. Various work has been published [16-20].

Instability of a Rotor System due to Journal Bearing (Oil Whip)

The basic concepts of oil whip were established by Hori [21]. The instability of the rotor system has been studied with practical models [22-30].

Instability of a Rotor System due to Fluid Forces

When fluid is accidentally trapped inside a high-speed rotor, the fluid causes instability at supercritical speeds [31-33]. Stability of centrifugal pumps [34] and self-induced oscillation due to aeroelastic tip clearance effect in turbomachinery [35] have been theoretically calculated.

The aeroelastic instability in labyrinth seals has been

studied [36-38]. In such an instability a pressure perturbation in the seal between the high and low pressure teeth can cause an elastic response of the seal rotor or stator element about a virtual pivot point located on the high or lower pressure side of the seal.

Instability due to Ball Bearings
The vibration of a rotor supported by ball bearings is caused by structural, manufacturing, or construction errors of ball bearings, the rotating shaft, and pedestals.

Instability factors include those within the pedestal:

- P_1; *misalignment of centerlines of both pedestals;*
- P_2; noncircularity of housing;
- P_3; flaw or dust on the housing plane;
- P_4; loosening of the pedestals; and
- P_5; flexibility of the pedestals.

Instability factors within ball bearings include:

- B_1; inequality of radius of balls;
- B_2; noncircularity of outer radius of outer ring;
- B_3; deviation of groove of outer ring from the circular plane;
- B_4; misalignment of centerlines of outer and inner circles of outer ring;
- B_5; noncircularity of inner circle of inner ring; and
- B_6; deviation of groove of inner ring from the circular plane.

Instability factors within the rotating shaft include:

- S_1; noncircularity of the journal;
- S_2; flaw or dust on the journal;
- S_3; deflection of shaft; and
- S_4; horizontal shaft.

Vibrations can occur because of one or more of the factors given above. Backward synchronous whirl is attributable to P_1, P_2, P_3, P_4, P_5, B_2, B_3, and B_4. Vibration due to noncircularity of radius of balls is due to B_1. Forced oscillation caused by passing the balls is caused by P_1, P_2, P_3, B_4, and S_4. Vibration due to responses of ball bearings in low-speed region is caused by P_1, P_2, B_3, and B_4 plus B_6, S_2, and S_3. Forced oscillation of one-half subharmonic type is due to P_1, P_3, P_4, B_3, and B_4. Forced oscillation of sum and difference type is caused by P_1, P_3, P_4, B_3, and B_4. Oscillations of the type $\pm 2\omega$, $\pm 3\omega$, $\pm 4\omega$ are due to P_1, P_3, B_3, and B_4 plus B_6, S_2, and S_3. Forced oscillation ($+2\omega$) of second order critical speed are caused by B_5, S_1, and S_2 plus S_4. Instability vibration is caused by B_5, S_1, and S_2. Vibration of ball bearings has been extensively studied [39-47].

Instability due to Universal Joint
When a rotor coupled by a universal joint (Hooke's joint) to a motor is driven by that motor, the angular velocity and torque of the rotor vary. The torque acts as a parametric exciting force [48-52].

Instability due to Rotor System Containing Asymmetric Factors
Factors that cause asymmetry have to do with the shaft, moment of inertia of the rotor, and the bearings. The effect of each factor and of combinations are important.

Consider the equation of motion: the asymmetry of the shaft, moment of inertia, and bearing. The equation of motion is written in the matrix form.

$$\left\{\begin{array}{l}[M+M(t)]\ddot{X}+(D+D(t))\dot{X}+(K+K(t))X+(K_R+K_R(t))X_L=0 \\ (K_R^T + K_R^T(t))X + (K_L + K_L(t))X_L = 0 \end{array}\right. \quad (8)$$

$(\cdot)^T$: Transverse of $(\cdot)$

Notations are shown in Figure 3

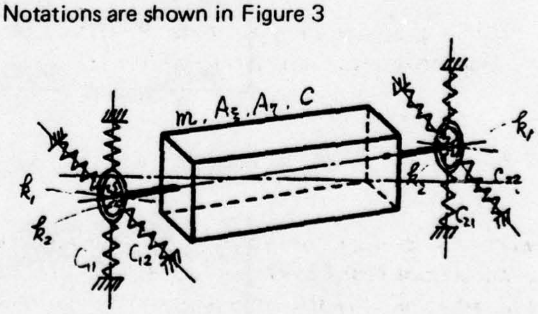

Figure 3. Rotor Model

$$M = \text{diag.}\ [m\ m\ A\ A]$$

$$M(t)=\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & -\Delta A\cos 2\omega t & -\Delta A\sin 2\omega t \\ 0 & 0 & -\Delta A\sin 2\omega t & \Delta A\cos 2\omega t \end{bmatrix}$$

$$D = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & c\omega \\ 0 & 0 & -c\omega & 0 \end{bmatrix}$$

$$D(t) = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 2\omega\Delta A\sin 2\omega & -2\omega\Delta A\cos 2\omega t \\ 0 & 0 & -2\omega\Delta A\cos 2\omega & -2\omega\Delta A\sin 2\omega t \end{bmatrix}$$

$$K = \begin{bmatrix} \alpha & 0 & \beta & 0 \\ 0 & \alpha & 0 & \beta \\ \beta & 0 & \gamma & 0 \\ 0 & \beta & 0 & \gamma \end{bmatrix}$$

$$K(t) = \begin{bmatrix} \Delta\alpha\cos 2\omega t & \Delta\alpha\sin 2\omega t & \Delta\beta\cos 2\omega t & \Delta\beta\sin 2\omega t \\ \Delta\alpha\sin 2\omega t & -\Delta\alpha\cos 2\omega t & \Delta\beta\sin 2\omega t & \Delta\beta\cos 2\omega t \\ \Delta\beta\cos 2\omega t & \Delta\beta\sin 2\omega t & \Delta\gamma\cos 2\omega t & \Delta\gamma\sin 2\omega t \\ \Delta\beta\sin 2\omega t & \Delta\beta\cos 2\omega t & \Delta\gamma\sin 2\omega t & \Delta\gamma\cos 2\omega t \end{bmatrix}$$

$$K_R = \begin{bmatrix} -k_1 & 0 & -k_2 & 0 \\ 0 & -k_1 & 0 & -k_2 \\ -k_1\ell_1 & 0 & k_2\ell_2 & 0 \\ 0 & -k_1\ell_1 & 0 & k_2\ell_2 \end{bmatrix}$$

$$K_R(t) = \begin{bmatrix} -\frac{\Delta k_1}{m}\cos 2\omega t & -\frac{\Delta k_1}{m}\sin 2\omega t & -\frac{\Delta k_2}{m}\cos 2\omega t & -\frac{\Delta k_2}{m}\sin 2\omega t \\ -\frac{\Delta k_1}{m}\sin 2\omega t & \frac{\Delta k_1}{m}\cos 2\omega t & -\frac{\Delta k_2}{m}\sin 2\omega t & \frac{\Delta k_2}{m}\cos 2\omega t \\ -\frac{\Delta k_1\ell_1}{A}\cos 2\omega t & -\frac{\Delta k_1\ell_1}{A}\sin 2\omega t & \frac{\Delta k_2\ell_2}{A}\cos 2\omega t & \frac{\Delta k_2\ell_2}{A}\sin 2\omega t \\ -\frac{\Delta k_1\ell_1}{A}\sin 2\omega t & \frac{\Delta k_1\ell_1}{A}\cos 2\omega t & \frac{\Delta k_2\ell_2}{A}\sin 2\omega t & -\frac{\Delta k_2\ell_2}{A}\cos 2\omega t \end{bmatrix}$$

$$K_L = \text{diag.}\,[C_{11} + k_1 \;\; C_{12} + k_1 \;\; C_{21} + k_2 \;\; C_{22} + k_2]$$

$$K_L(t) = \begin{bmatrix} \Delta k_1\cos 2\omega t & \Delta k_1\sin 2\omega t & 0 & 0 \\ \Delta k_1\sin 2\omega t & -\Delta k_1\cos 2\omega t & 0 & 0 \\ 0 & 0 & \Delta k_2\cos 2\omega t & \Delta k_2\sin 2\omega t \\ 0 & 0 & \Delta k_2\sin 2\omega t & -\Delta k_2\cos 2\omega t \end{bmatrix}$$

$$X^T = [x \;\; y \;\; \theta_x \;\; \theta_y]$$

$$X_L^T = [X_1 \;\; Y_1 \;\; X_2 \;\; Y_2]$$

$$k_1 = \tfrac{1}{2}(k_{11} + k_{12}) \quad , \quad \Delta k_1 = \tfrac{1}{2}(k_{11} - k_{12})$$

$$k_2 = \tfrac{1}{2}(k_{21} + k_{22}) \quad , \quad \Delta k_2 = \tfrac{1}{2}(k_{21} - k_{22})$$

$$
\begin{aligned}
A &= \tfrac{1}{2}(A_\xi + A_\eta) &, \quad \Delta A &= \tfrac{1}{2}(A_\xi - A_\eta)\\
C_1 &= \tfrac{1}{2}(C_{11} + C_{12}) &, \quad \Delta C_1 &= \tfrac{1}{2}(C_{11} - C_{12})\\
C_2 &= \tfrac{1}{2}(C_{21} + C_{22}) &, \quad \Delta C_2 &= \tfrac{1}{2}(C_{21} - C_{22})\\
\alpha &= k_1 + k_2 &, \quad \Delta\alpha &= \Delta k_1 + \Delta k_2\\
\beta &= k_1\ell_1 - k_2\ell_2 &, \quad \Delta\beta &= \Delta k_1\ell_1 - \Delta k_2\ell_2\\
\gamma &= k_1\ell_1^2 + k_2\ell_2^2 &, \quad \Delta\gamma &= \Delta k_1\ell_1^2 + \Delta k_2\ell_2^2
\end{aligned}
$$

Equation (8) without an asymmetric factor of moment of inertia was first discussed by Smith [53]. Equation (8) containing all factors has been systematically discussed [54]. Stability was discussed for each combination of asymmetric factors. Each combination of asymmetric factors has been studied; see the Table.

With a symmetric bearing, asymmetric shaft, and with rotational inertia, $c_{11} = c_{12}$ and $_{c}c_{21} = c_{22}$. The equation of motion, is therefore similar to the case of a fixed support bearing system. Rewrite the equations of motion in a coordinate system that rotates at shaft speed,

$$
\begin{aligned}
&M_\xi \ddot{\xi} + D_\xi \dot{\xi} + (K_\xi + K_{\xi R})\,\xi = 0\\
&K_{\xi R}^T\,\xi + (K_{\xi L} + K_{\xi L}(t))\xi_L = 0
\end{aligned}
\qquad (9)
$$

where M_ξ, D_ξ, $K_{\xi R}$, $K_{\xi L}$, and are constant matrices.

$$
K_{\xi L}(t) = \begin{matrix}
\Delta C_1\cos 2\omega t & -\Delta C_1 \sin 2\omega t & 0 & 0\\
-\Delta C_1 \sin 2\omega t & -\Delta C_1\cos 2\omega t & 0 & 0\\
0 & 0 & \Delta C_2 \cos 2\omega t & -\Delta C_2 \sin 2\omega t\\
0 & 0 & -\Delta C_2 \sin 2\omega t & -\Delta C_2\cos 2\omega t
\end{matrix}
$$

$$\xi^T = [\xi \;\; \eta \;\; \theta_\xi \;\; \theta_\eta]$$

$$\xi_L^T = [\,\Xi_1 \;\; H_1 \;\; \Xi_2 \;\; H_2\,]$$

Set $c_{11} = c_{12}$, $c_{21} = c_{22}$, $\Delta c_1 = \Delta c_2 = 0$, and $K_{\xi L}(t) = 0$. Equation (9) becomes a constant coefficient differential equation. Work has been published for discrete systems [55-67] and continuous systems [68-71].

With a symmetric shaft and bearings and a system with asymmetric rotational inertia, $\Delta k_1 = \Delta k_2 = 0$, $c_{12} = c_{11}$, $c_{21} = c_{22}$; thus, $\Delta\alpha = \Delta\beta = \Delta\gamma = 0$ $\Delta C_1 = \Delta C_2 = 0$ in the coefficient matrix, equation (9). The equation of motion becomes a constant coefficient differential equation [72-75].

With a symmetric system having rotational inertia, an asymmetric shaft, and bearings, set $\Delta A = 0$ in equation (8). The equation of motion is

$$
\begin{cases}
M\ddot{X} + D\dot{X} + (K + K(t))X + (K_R + K_R(t))X_L = 0\\
(K_R^T + K_R^T(t))X + (K_L + K_L(t))X_L = 0
\end{cases}
\qquad (10)
$$

There is a time-varying coefficient; the investigation has been well developed for discrete systems [75-80] and for continuous systems [80].

With symmetric rotational inertia, bearings, and an asymmetric shaft system, set $A = 0$, $c_{12} = c_{11}$, $c_{21} = c_{22}$. Equation (9) formulated as a rotating coordinate system has the same form as equation (9) or has a constant coefficient matrix. Because the analysis is not difficult, this problem has been studied very well for discrete systems [82-84] and for continuous systems [85-87].

In a two-pole turbogenerator, the magnetic force between rotor and stator differs two times in one cycle. This phenomenon is similar to the case just described [88].

Table. Combination of Asymmetric Factors

	Case						
Element	0	1	2	3	4	5	6
Shaft	Asym.	Asym.	Asym.	Asym.	Sym.	Sym.	Sym.
Bearing	Asym.	Asym.	Sym.	Sym.	Sym.	Asym.	Asym.
Moment of Inertia	Asym	Sym.	Sym.	Asym.	Asym.	Sym.	Asym.

With a system having a symmetric shaft, rotational inertia, and asymmetric bearings, set A = 0, $\Delta\alpha = \Delta\beta = \Delta\gamma = 0$. Equation (8) becomes

$$\begin{cases} M\ddot{X} + D\dot{X} + KX + K_R X_L = 0 \\ K_R^T X + K_L X_L = 0 \end{cases} \tag{11}$$

The equation of motion has constant coefficients [89].

A system consisting of a symmetric shaft, asymmetric rotational inertia, and bearings system has never been studied.

Finally, rotor systems under a parametric exciting force have been studied [90, 91], as have nonlinear rotor vibrations [92-97].

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BOOK REVIEWS

STRESS WAVES IN NON-ELASTIC SOLIDS

W.K. Nowacki

Pergamon Press, Oxford (1978)

This book (translated from Polish) summarizes research to 1974 in a continuum mechanics treatment of wave propagation in inelastic materials. Mainly, characteristic solutions are described for small strain problems with constitutive descriptions relevant to both metals and soils. The review is especially complete for results published by Polish workers. It has an extensive bibliography.

Nowacki first describes several theories of plasticity for small strains considering yield functions that allow for hardening and rate sensitivity. Solutions are then presented for a number of problems of loading and unloading according to some time-dependent compressive stress boundary condition. Some involve solution by the finite difference method along characteristics but most are closed form solutions.

The longest chapter deals with bar waves; i.e., plane longitudinal waves of uniaxial stress. Some uniaxial strain problems are also treated. Cases of stress-strain relations of both concavities (upward and downward) are treated. Problems of reflection from obstacles are also dealt with. The next longest chapter considers plastic longitudinal-transverse waves. This is an area in which the author has made a substantial contribution, especially in non-self-similar problems. Nonhomogeneous media are treated, as well as beams, plates, and plane two-dimensional stress waves. Shorter chapters treat spherical and cylindrical waves, and stress waves due to thermal shock. A list of conclusions is typically given at the end of each development.

I recommend this book to workers in the field of solid mechanics, as it brings together considerable research on problems in plastic wave propagation. Little contact is made with experimental results by the author, limiting the book's usefulness. The printing is not of uniformly good quality, and there are a few printing errors in equations and some confusing notation.

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ACOUSTIC DESIGN AND NOISE CONTROL VOLUME 1, ACOUSTIC DESIGN

M. Rettinger

Chemical Publishing Co., Inc., New York (1977)

This, the first of two volumes, is virtually a reprint of half of an earlier text (1973) of essentially the same title by the same author and the same publisher. There does not appear to have been any significant updating or revision of the 1973 version, a review of which appeared in the DIGEST (6, July 1974).

An indication of the lack of updating is the statement that useful publications by the Acoustical Materials Association are available. Unfortunately, that organization has, after several attempts to reorganize, apparently closed its doors; its last booklet was published in 1975 while the organization was called the American Board Products Association.

A number of highly personalized accounts in the book make pleasant reading, but not all of the acoustical design information should be taken as gospel. Some of the acoustical design guidelines do not rest on correct physical principles. For example, the suggestion that noise sensitive buildings be set well back from roads is a good one but not because the hard ground in between causes the spreading loss to be 3 dB/distance doubled rather than 6. Such placement does not alter the 6 dB per doubling rate due to spherical spreading. The hard surface can raise the sound pressure level of the source for a

given acoustic power level, perhaps as much as 3 dB. In addition, a blanket condemnation is made of concrete as a structural material in high-rise buildings because of its relatively low internal loss factor. This negative aspect of concrete should have been balanced against its high structural impedance which allows such simple isolation methods as carpeting to be highly effective in reducing impact sound and springs that isolate machinery vibrations. Carpet laid on a wooden floor in a frame building would not reduce the foostep noise anywhere nearly as well as carpet in a concrete structure. Furthermore, the loss factor in steel structures is even lower, roughly an order of magnitude, than that in reinforced concrete.

Much of the discussion of auditorium acoustics neglects the critical aspect of scattering and places heavy emphasis on the traditional concepts of ray tracing and the assumption of an ideal diffuse field.

Although one can easily criticize many of the details of the book, it is a lively account of a wide variety of topics in room acoustics and contains much usable information. It is, however, not recommended as a definitive reference book on the subject. The reason for reprinting a text, dividing it into two volumes, and falsely implying that two new books have been created are probably logical only to someone in the publishing business.

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STOCHASTIC PROBLEMS IN MECHANICS

S.T. Ariartnam and H.H.E. Leipholz, editors
University of Waterloo, Canada

This unusual book is based on a symposium held in September, 1973, at the University of Waterloo; participation was by invitation. Each of the six chapters focuses on a general area and contains specific information on stochastic processes.

The first chapter is an introduction to the general theory of stochastic processes and includes discussions of stationarity, the Kolmo-Gorov-Fokker-Planck equation, and response phenomena. Probability in optimization and decision problem in design are also described, as is a mathematical approach to deformation of structural media using an operational application.

The second chapter concerns dynamic systems. The initial paper discusses control of dynamic systems during uncertain disturbances. Other papers consider stochastic aspects of dynamic systems with application to Markov processes and beam analysis, including stability of weak stochastic linear systems, application of martingale theory to optimum filtering, and modeling of earthquake data by stochastic means. This last is informative because most analyses having to do with response to earthquakes are based on shock spectrum responses.

The third chapter describes structural systems. A paper on identification of structural systems using test data has been a subject of much research effort. Other papers consider reliability of imperfect systems, dynamic buckling of structures with random imperfections, and probabilistic treatments of column buckling problems.

The fourth chapter addresses simulation and numerical methods. The first two papers consider digital simulation via FFT techniques of a random process and simulation of a narrow-band random system. The third paper considers a spectral analysis of randomly sampled systems, a new field with applications to many areas of flow measurements. Recent applications have been concerned with wind tunnel measurements and flow measurements of rotating machinery. The last paper considers an experimental investigation of random cutting forces in a turning operation and has direct application to machining.

The fifth chapter is concerned with fatigue. Most tests and analyses have concentrated upon constant amplitude tests. The fairly new topic of random fatigue is introduced by defining random fatigue, the way it is evaluated from tests, and when it can be applied in reliability processes. Additional papers discuss fatigue damage in composite flawed plate specimens and combination of static (mean) stress and random imposed vibratory stresses. The reviewer would have liked more experimental papers on this subject.

The last chapter considers two old subjects -- hydrology and fluid mechanics -- in new wrappings -- random processes. During the last two decades, hydrology and fluid mechanics have progressed from a deterministic world to a random world. The initial paper considers stochastic aspects in hydrology. The second paper discusses peak distribution and wave number spectra of surface waves. The last two papers dwell on wave propagation along a random boundary and stochastic prediction of extreme waves and sediment transport. This chapter concentrates on recent aspects of random theory applied to fluid motion.

This book is thus of current interest. It includes information about a number of subjects that have in common stochastic processes. The various papers inform the interested reader of the important role that stochastic processes play in mechanics. The reviewer would like to see more symposia of this nature and more detailed experimental and analytical endeavors in mechanics of stochastic systems. The book is recommended to those interested in obtaining either an introduction to stochastic processes or a broad description of random responses.

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Schenectady, NY 12345

SHORT COURSES

MARCH

DYNAMIC ANALYSIS OF STRUCTURES
Dates: March 19-22, 1979
Place: Detroit, Michigan
Objective: This seminar provides practical laboratory experience on getting good data and recognizing bad; diagnosing machinery with Vibration Spectrum Analyzers; solving structural problems with Transfer Function Analyzers; and demonstrations using state of the art FFT processors.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

APRIL

RANDOM VIBRATION AND ACOUSTIC NOISE
Dates: April 2-4, 1979
Place: The Open University, Milton Keynes, UK
Objective: The course will cover the following topics: descriptions of vibration and acoustic data; response properties of mechanical systems; probability and amplitude functions; correlation and spectral density functions; data collection, processing and analysis; applications to vibration prediction problems; applications to frequency response estimation problems; applications to multipath propagation problems; applications to source localization problems; and applications to structural and equipment failure prediction problems.

Contact: Dr. M.A. Dorgham, Faculty of Technology, The Open University, Walton Hall, Milton Keynes MK7 6AA, UK - (0908) 63945.

VIBRATION AND SHOCK SURVIVABILITY
Dates: April 2-6, 1979
Place: Wilmington, Massachusetts
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 E. Olivos St., Santa Barbara, CA 93105 - (805) 963-1124.

MACHINERY VIBRATION MONITORING AND ANALYSIS SEMINAR
Dates: April 10-12, 1979
Place: New Orleans, Louisiana
Objective: This seminar will be devoted to the understanding and application of vibration technology to machinery vibration monitoring and analysis. Basic and advanced techniques with illustrative case histories and demonstrations will be discussed by industrial experts and consultants. Topics to be covered in the seminar include preventive maintenance, measurements, analysis, data recording and reduction, computer monitoring, acoustic techniques, misalignment effects, balancing, mechanical impedance and mobility, turbomachinery blading, bearing fault diagnosis, torsional vibration problems and corrections, and trend analysis. An instrumentation show will be held in conjunction with this seminar.

Contact: Dr. R.L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th St., Clarendon Hills, IL 60514 - (312) 654-2254.

CORRELATION AND COHERENCE ANALYSIS FOR ACOUSTICS AND VIBRATION PROBLEMS
Dates: April 16-20, 1979
Place: UCLA
Objective: This course covers the latest practical techniques of correlation and coherence analysis (ordinary, multiple, partial) for solving acoustics and vibration problems in physical systems. Procedures currently being applied to data collected from single, multiple and distributed input/output systems are explained to: classify data and systems; measure propagation times; identify source contributions;

evaluate and monitor system properties, predict output responses and noise conditions; determine nonlinear and nonstationary effects; and conduct dynamics test programs.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

APPLIED TIME SERIES ANALYSIS
Dates: April 23-27, 1979
Place: UCLA
Objective: This course is intended for users of digital time series who require modern methods of data analysis. Topics include data collection and processing, digital filtering, filter design and stability, statistical problems in data analysis, fast Fourier transform and its implementation, power spectral density calculations and input transform functions from data.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

NOISE-CON SEMINAR
Dates: April 26-28, 1979
Place: Purdue University
Objective: This seminar will emphasize the fundamentals of noise control engineering, machinery noise control, in-plant noise, and measurements and facilities for noise control. This is the eighth Seminar which has been organized by the Institute to acquaint individuals just entering the field with the basic principles of noise control and with practical methods for control of machinery and in-plant noise.

Contact: NOISE-CON Seminar, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719.

EARTHQUAKE ANALYSIS OF MULTISTORY FRAME AND SHEARWALL BUILDINGS
Dates: April 30 - May 1, 1979
Place: University of California, Berkeley
Objective: This seminar is intended for engineers involved in the design and analysis of earthquake-resistant structures. It will be devoted to the practical application and use of computer programs for static and dynamic analysis. Among the programs discussed will be TABS, ETABS, DRAIN 2D, and DRAIN-TABS, which have a proven history of successful application to building earthquake studies.

Contact: Continuing Education in Engineering, University of California Extension, 2223 Fulton St., Berkeley, CA 94720 - (415) 642-4151.

MAY

MACHINERY VIBRATION ANALYSIS
Dates: May 8-10, 1979
Place: San Diego, California
Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories; improving your analysis capability; managing vibration data by computer; and dynamic analysis.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

THE FIFTH ANNUAL RELIABILITY TESTING INSTITUTE
Dates: May 14-18, 1979
Place: University of Arizona
Objective: To provide reliability engineers, product assurance engineers and managers and all other engineers and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, and reliabilities; small sample size, short duration, low cost tests, and methods of analyzing their results; Bayesian testing; suspended items testing; sequential testing; and others.

Contact: Special Professional Education, College of Engineering, University of Arizona, Old Engineering Bldg., Tucson, AZ 85721 - (602) 626-3054.

STRUCTURED PROGRAMMING AND SOFTWARE ENGINEERING
Dates: May 21-25, 1979

Place: The George Washington University
Objective: This course provides up-to-date technical knowledge of logical expression, analysis, and invention for performing and managing software architecture, design, and production. Presentations will cover principles and applications in structures programming and software engineering, including stepwise refinement, program correctness, and top-down system development.

Contact: Continuing Engineering Education Program, George Washington University, Washington, D.C. 20052 - (202) 676-6106 or toll free (800) 424-9773.

JUNE

ACOUSTIC EMISSION STRUCTURAL MONITORING TECHNOLOGY

Dates: June 18-19, 1979
Place: Los Angeles, California
Objective: A theory and practice course covering each of the various facets of acoustic emission structural monitoring technology; basic phenomena, state-of-the-art applications, field testing experience, applicable codes and standards and instrumentation design and calibration. This course also includes "hands-on" operation of minicomputer and microcomputer acoustic emission systems. This course is designed for potential users of acoustic emission structural monitoring systems.

Contact: C.A. Parker, Nuclear Training Center, Atomics International, P.O. Box 309, Canoga Park, CA 91304 - (213) 341-1000, Ext. 2811.

AUGUST

THE SCIENTIFIC AND MATHEMATICAL FOUNDATIONS OF ENGINEERING ACOUSTICS

Dates: August 13-24, 1979
Place: Massachusetts Institute of Technology
Objective: The program emphasizes those parts of acoustics -- the vibration of resonators, properties of waves in structures and air – the generation of sound and its propagation that are important in a variety of fields of application. The mathematical procedures that have been found useful in developing the desired equations and their solutions, and the processing of data are also studied. These include complex notation, fourier analysis, separation of variables, the use of special functions, and spectral and correlation analysis.

Contact: Richard H. Lyon, Massachusetts Institute of Technology, Room 3-366, Dept. of Mech. Engrg., Cambridge, MA 02139.

NOVEMBER

DYNAMIC ANALYSIS WORKSHOP

Dates: November 5-9, 1979
Place: San Diego, California
Objective: This course will cover the latest techniques of analyzing noise and vibration in rotating machinery and power-driven structures. The workshop will cover both the theory and practical aspects of tracking down malfunctions and preventing failures caused by unbalance, misalignment, wear, oil whirl, etc. Included in the course will be demonstrations and practical, hands-on experience with the latest noise and vibration instrumentation: Real Time Analyzers, FFT Processors, Transfer Function Analyzers and Computer-Controlled Modal Analysis Systems. Actual case histories and specific machinery signatures will be discussed.

Contact: Spectral Dynamics Training Manager, P.O. Box 671, San Diego, CA 92112 - (714) 565-8211.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

PROCEEDINGS OF PAST CONFERENCES ARE AVAILABLE

The Institute of Noise Control Engineering has sponsored a series of International Conferences on Noise Control (the INTER-NOISE series) and a series of National Conferences on specialized topics in noise control (the NOISE-CON series). To date, seven International Conferences (one each year, 1972 - 1978) and three National Conferences (1973, 1975, 1977) have been held. INTER-NOISE 79 will be held in Poland in September of 1979 and NOISE-CON 79, with the theme "Machinery Noise Control," will be held at Purdue University in West Lafayette, Indiana on April 30-May 2, 1979.

A limited number of copies of all of the Proceedings of past Conferences are still available, including the Proceedings of the International Conferences held overseas in Copenhagen in 1973, Sendai (Japan) in 1975, and Zurich in 1977.

Information on the contents of each volume, prices, airmail surcharges and other information may be obtained from the Institute of Noise Control Engineering, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603.

NOISE/NEWS BEGINS EIGHTH YEAR OF PUBLICATION

NOISE/NEWS, published bimonthly for the Institute of Noise Control Engineering, begins its eighth year of serving the noise control community with the January-February 1979 issue. During this period, there were two very significant bills passed by the U.S. Congress: the Noise Control Act of 1972 and the Quiet Communities Act of 1978. The Occupational Safety and Health Administration (OSHA) also took important steps towards a revision of its workplace noise regulation and federal agencies such as EPA and DOT have issued many proposals and regulations concerning noise. All of these items have been regularly reported in ***NOISE/NEWS***. More than 1500 government reports on noise have been listed, and contract award information is also published. Standards news and news of national and international noise Conferences appears in each issue.

A limited number of specimen copies of ***NOISE/NEWS*** are available upon request in order to acquaint potential readers with its content. Copies may be obtained by writing to NOISE/NEWS, P.O. Box 1758, Poughkeepsie, NY 12603.

FREE VOLUMES OF NOISE CONTROL ENGINEERING FOR NEW INCE ASSOCIATES

The Institute of Noise Control Engineering has announced that two free volumes (six issues) of the bimonthly technical publication ***Noise Control Engineering*** will be given to individuals who become new Associates of the Institute in 1979. The offer, intended to encourage individuals interested in noise and its control to participate in the activities of the Institute, will enable new Associates to begin building a library of back issues of ***Noise Control Engineering***, the only publication in the United States which publishes refereed articles devoted exclusively to noise control.

Any individual interested in noise control may become an Associate of INCE; Associates receive the bimonthly publication ***Noise/News*** in addition to ***Noise Control Engineering***. Associates also receive mailings of meeting programs of National and International Conferences organized by the Institute.

The INCE Associate application form and specimen copies of both ***Noise Control Engineering*** and ***Noise/News*** are available from the Membership Secretariat, INCE, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603.

ABSTRACT CATEGORIES

ANALYSIS AND DESIGN

Analogs and Analog Computation
Analytical Methods
Dynamic Programming
Impedance Methods
Integral Transforms
Nonlinear Analysis
Numerical Analysis
Optimization Techniques
Perturbation Methods
Stability Analysis
Statistical Methods
Variational Methods
Finite Element Modeling
Modeling
Digital Simulation
Parameter Identification
Design Information
Design Techniques
Criteria, Standards, and Specifications
Surveys and Bibliographies
Tutorial
Modal Analysis and Synthesis

COMPUTER PROGRAMS

General
Natural Frequency
Random Response
Stability
Steady State Response
Transient Response

ENVIRONMENTS

Acoustic
Periodic
Random
Seismic
Shock
General Weapon
Transportation

PHENOMENOLOGY

Composite
Damping
Elastic
Fatigue
Fluid
Inelastic
Soil
Thermoelastic
Viscoelastic

EXPERIMENTATION

Balancing
Data Reduction
Diagnostics
Equipment
Experiment Design
Facilities
Instrumentation
Procedures
Scaling and Modeling
Simulators
Specifications
Techniques
Holography

COMPONENTS

Absorbers
Shafts
Beams, Strings, Rods, Bars
Bearings
Blades
Columns
Controls
Cylinders
Ducts
Frames, Arches
Gears
Isolators
Linkages
Mechanical
Membranes, Films, and Webs
Panels
Pipes and Tubes
Plates and Shells
Rings
Springs
Structural
Tires

SYSTEMS

Absorber
Acoustic Isolation
Noise Reduction
Active Isolation
Aircraft
Artillery
Bioengineering
Bridges
Building
Cabinets
Construction
Electrical
Foundations and Earth
Helicopters
Human
Isolation
Material Handling
Mechanical
Metal Working and Forming
Off-Road Vehicles
Optical
Package
Pressure Vessels
Pumps, Turbines, Fans, Compressors
Rail
Reactors
Reciprocating Machine
Road
Rotors
Satellite
Self-Excited
Ship
Spacecraft
Structural
Transmissions
Turbomachinery
Useful Application

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

NONLINEAR ANALYSIS

79-396

Nonlinear Dynamic Response of Reinforced Concrete Under Impulsive Loading: Research Status and Needs

O. Buyukozturk and J.J. Connor

Dept. of Civil Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, Nucl. Engr. Des., 50 (1), pp 83-92 (1978) 10 figs, 31 refs

Key Words: Reinforced concrete, Dynamic response, Nonlinear theories

Current research status is presented for the multidimensional nonlinear analysis of reinforced concrete subjected to impulsive load conditions. Strategy for the solution of nonlinear dynamic equations is discussed. The description of the development of models for material behavior is given. Further research needs and interests for the development of improved analysis capabilities are indicated.

NUMERICAL ANALYSIS

79-397

Vulnerability Analysis of Optimized Structures

V.B. Venkayya, N.S. Khot, and F.E. Eastep

Air Force Flight Dynamics Lab., Wright-Patterson Air Force Base, OH, AIAA J., 16 (11), pp 1189-1195 (Nov 1978) 3 figs, 2 tables, 20 refs

Key Words: Vulnerability, Stiffness, Iteration, Optimum design, Finite element technique, Aircraft

An iterative method for the analysis of damaged structures is presented in the context of the displacement method of finite-element analysis. The method consists of first finding the solution of the undamaged structure and then determining the perturbed solution due to the damage by using the first two terms of the Taylor's series expansion of the initial solution. The elastic analysis of the effects of the damage, the elastoplastic analysis of the effects of material yielding, and the estimation of the loss of frequency and mode shape deterioration are discussed. A brief discussion of a criterion for convergence of the solution and an empirical definition of the extent of damage is included. Applications of the procedure to an airplane wing structure and a truss are presented.

STATISTICAL METHODS

(See Nos. 429, 430)

FINITE ELEMENT MODELING

79-398

Dynamic Finite Element Analysis of Cracked Bodies

J.L. Glazik, Jr.

Argonne National Lab., Argonne, IL, ASME Paper No. 78-PVP-94

Key Words: Cracked media, Finite element technique, Dynamic structural analysis

Application of the finite element method to problems involving cracked bodies subjected to impact loadings is discussed. Mass matrices for a simple, well-established singular element have been developed and applied to the problem of a centrally cracked strip whose ends are loaded by a step tensile stress. The results agree well with those obtained by using a much higher order singular element. Results are also presented for this problem employing an equally coarse finite element mesh with no singular element at all, and good agreement is demonstrated.

79-399

Finite Elements for Nonlinear Eigenvalue Problems with Applications in Post-Buckling Behavior of Structures and Structural Dynamics

G.M. Dib

Ph.D. Thesis, Univ. of Southern California (1978) Avail: Micrographics Dept., Doheny Library, USC, Los Angeles, CA 90007

Key Words: Finite element technique, Eigenvalue problems, Nonlinear theories

Development of finite element formulations for specific problems (i.e., nonlinear eigenvalue problems) involving either multi-valued solutions, stability, bifurcation, or branching behavior is considered. Finite element variational approximations are developed for this formulation. In particular, problems of post-buckling of structures and nonlinear structural dynamics are considered.

79-400
A New Algorithm for Integration of Dynamic Systems
M. Gellert
Dept. of Civil Engrg., Technion Israel Inst. of Tech., Haifa, Technion City, Israel, Computers Struc., 9 (4), pp 401-408 (Oct 1978) 5 figs, 11 tables, 8 refs

Key Words: Finite element technique, Dynamic systems

A high precision unconditionally stable algorithm for computation of linear dynamic structural systems is described. Local truncation error analysis is made and rate of convergence is proved. Applications to problems allowing comparison with existing results are presented. Excellent agreement with exact solutions is achieved.

DESIGN TECHNIQUES

79-401
Redesign of Structural Vibration Modes by Finite Element Inverse Perturbation
K.A. Stetson, I.R. Harrison, and B.N. Cassenti
United Technologies Res. Center, East Hartford, CT, Rept. No. UTRC/R77-992945, AFAPL-TR-78-21, 70 pp (May 1978)
AD-A057 662/9GA

Key Words: Design techniques, Computer-aided techniques, Finite element techniques, Perturbation theory

The application of the inverse perturbation method, originally developed at United Technologies Research Center, directly to the output of a finite element computer analysis of a structure is demonstrated. A new structural design tool has been developed which has the potential for application to the mathematically complex structure of a turbine blade. The initial step in this direction was the redesign of a flat plate and a 45 degree arc of a cylindrical shell, both mounted as cantilever beams. Included in the report, in addition to a detailed review of the contract work, is an overview of the concept of inverse perturbation, and a detailed description of previous UTRC work on redesigning structural vibration modes by inverse perturbation subject to minimal change theory.

CRITERIA, STANDARDS, AND SPECIFICATIONS

(See No. 519)

SURVEYS AND BIBLIOGRAPHIES

79-402
Mechanical Damping of Filled Plastics
L.E. Nielsen
Plastics Consultant, Redmond, OR 97756, Shock Vib. Dig., 10 (10), pp 9-11 (Oct 1978) 12 refs

Key Words: Reviews, Damping, Plastics

The effects of filler agglomeration on damping and mechanical behavior are reviewed. It has been found that damping and elastic moduli of filled plastics are very sensitive to the state of agglomeration of filler particles.

79-403
Summary of NASA Landing-Gear Research
B.D. Fisher, R.K. Sleeper, and S.M. Stubbs
Langley Res. Center, NASA, Langley Station, VA, In: CTOL Transport Technol., pp 773-804 (1978)
N78-29056

Key Words: Reviews, Landing gear

Research relative to tire tread, powered-wheel taxiing, air cushion landing systems, and crosswind landing gear is discussed.

79-404
Marine Propellers: Fluid Mechanics and Mechanical Properties (Citations from the Engineering Index Data Base)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA, 114 pp (Sept 1978)
NTIS/PS-78/1026/0GA

Key Words: Bibliographies, Marine propellers, Mechanical properties, Noise generation

Various configurations of marine propellers are investigated. Mechanical properties, fluid dynamic and hydrodynamic properties, and propeller noise are among the parameters researched. This updated bibliography contains 108 abstracts, 20 of which are new entries to the previous edition.

79-405
Marine Propellers: Fluid Mechanics and Mechanical Properties (Citations from the NTIS Data Base)

National Technical Information Service, Springfield, VA, 234 pp (Sept 1978)
NTIS/PS-78/1025/2GA

Key Words: Bibliographies, Marine propellers, Mechanical properties, Noise generation

Various configurations of marine propellers are investigated. Mechanical properties, fluid dynamic and hydrodynamic properties, and propeller noise are among the parameters investigated. This updated bibliography contains 228 abstracts, 15 of which are new entries to the previous edition.

79-406
Noise Control for Motor Vehicles (Citations from the NTIS Data Base)
D.M. Cavagnaro
National Technical Information Service, Springfield, VA, 79 pp (Sept 1978)
NTIS/PS-78/1010/4GA

Key Words: Bibliographies, Motor vehicles, Noise reduction, Automobiles, Trucks, Buses, Engine mufflers, Tires

These citations cover different methods to control noise generated by motor vehicles. Although most of the studies concern trucks, automobiles, buses, and motorcycles are also covered. The bibliogrpahy discusses engine noise suppression, mufflers, and tire noise reduction.

79-407
Noise Control for Motor Vehicles (Citations from the Engineering Index Data Base)
D.M. Cavagnaro
National Technical Information Service, Springfield, VA, 159 pp (Sept 1978)
NTIS/PS-78/1011/2GA

Key Words: Bibliographies, Motor vehicles, Noise reduction, Automobiles, Trucks, Buses, Engine mufflers, Tires

The controlling of noise from different types of motor vehicles is discussed in these citations. The cited research reports cover noise control through tire, muffler, and engine design. The types of vehicles studied include automobiles, trucks, buses, and motorcycles.

79-408
Engine/Airframe/Drive Train Dynamic Interface Documentation
M.A. Bowes
Kaman Aerospace Corp., Bloomfield, CT, Rept. No. USARTL-TR-78-14, 24 pp (June 1978)
AD-A058 197/5GA

Key Words: Reviews, Helicopter engines, Rotary wings, Rotors, Drive shafts, Resonant response

An historical review of Kaman Aerospace Corporation helicopter development effort was conducted. Information pertaining to instances of engine/airframe/drive train incompatibility was extracted from the resulting review data. The details of each incompatibility problem and its solution are presented and discussed. These problems were found to be associated with normally occurring rotor and drive system vibratory excitations and resonance amplified rotor and drive system vibratory excitations.

79-409
Roofs and Roofing Technology. Volume 1. 1964 - 1974 (A Bibliography with Abstracts)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA, 154 pp (Sept 1978)
NTIS/PS-78/1012/0GA

Key Words: Bibliographies, Roofs

Structural properties, thermal analyses, and dynamic responses under loads of roofs and roofing materials are investigated. Optimum design configurations are studied. Heat loss phenomena through roofs and waterproofing techniques are researched.

79-410
Roofs and Roofing Technology. Volume 2. 1975 - August 1978 (A Bibliography with Abstracts)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA, 80 pp (Sept 1978)
NTIS/PS-78/1013/8GA

Key Words: Bibliographies, Roofs

Structural properties, thermal analyses, and dynamic responses under loads of roofs and roofing materials are investigated. Optimum design considerations are studied. Heat loss phenomena through roofs and waterproofing techniques are researched.

79-411
Earthquake Engineering: Buildings, Bridges, Dams

and Related Structures. Volume 2. 1974 - September 1977 (A Bibliography with Abstracts)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA, 372 pp (Sept 1978)
NTIS/PS-78/0941/1GA

Key Words: Bibliographies, Buildings, Bridges, Dams, Earthquake resistant structures, Seismic response

Seismic phenomena relative to buildings, bridges, dams, and other structures are investigated. Damage assessment is made and design inadequacies are revealed. Suggestions for structural improvements for dynamic response are presented. Abstracts on site selection and earthquake-proofing for atomic power plants are included. This updated bibliography contains 365 abstracts, none of which are new entries to the previous edition.

79-412
Earthquake Engineering: Buildings, Bridges, Dams and Related Structures. Volume 3. October 1977 - August 1978 (A Bibliography with Abstracts)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA, 119 pp (Sept 1978)
NTIS/PS-78/0942/9GA

Key Words: Bibliographies, Buildings, Bridges, Dams, Earthquake resistant structures, Seismic response

Seismic phenomena relative to buildings, bridges, dams, and other structures are investigated. Damage assessment is made and design inadequacies are revealed. Suggestions for structural improvements for dynamic response are presented. Abstracts on site selection and earthquake-proofing for atomic power plants are included. This updated bibliography contains 112 abstracts, all of which are new entries to the previous edition.

79-413
Transmission Line Vibrations
V. Ramamurti, S. Sathikh, and R.T. Chari
Indian Inst. of Tech., Madras 600036, India, Shock Vib. Dig., 10 (11), pp 27-31 (Nov 1978) 63 refs

Key Words: Reviews, Transmission lines, Vibration dampers, Strings

This article briefly reviews the general behavior of transmission lines, vibration dampers, bundle conductors, and spacers.

79-414
Thermomechanical Vibrations
T.J. Chung
Dept. of Mech. Engrg., The Univ. of Alabama in Huntsville, P.O. Box 1247, Huntsville, AL 35807, Shock Vib. Dig., 10 (11), pp 17-25 (Nov 1978) 63 refs

Key Words: Reviews, Thermal excitation, Fiber composites

This article surveys dynamic problems in thermomechanics. A special case has to do with nonlinear thermomechanical response in fiber composites. Linear and nonlinear vibration problems in thermomechanics are associated with elasticity, viscoelasticity, plasticity, and magnetoelasticity. The generalized thermoelasticity dealing with second sound is also discussed.

79-415
Band Saw Vibration and Stability
A.G. Ulsoy and C.D. Mote, Jr.
Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, Shock Vib. Dig., 10 (11), pp 3-15 (Nov 1978) 6 figs, 2 tables

Key Words: Reviews, Saws, Moving strips

This paper evaluates the most significant research achievements reported in the international band saw vibration and stability literature. Fundamental research developments in vibrations that are useful in other areas of research, as well as active and potentially fruitful research areas, are emphasized.

79-416
Recent Progress in the Dynamic Plastic Behavior of Structures. Part II
N. Jones
Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139, Shock Vib. Dig., 10 (10), pp 13-19 (Oct 1978) 13 refs

Key Words: Reviews, Dynamic plasticity, Beams, Plates, Shells, Structural elements

This two-part article reviews the literature on the dynamic plastic response of structures published since 1975. The review focuses on the behavior of such simple structural components as beams, plates, and shells subjected to dynamic loads that cause extensive plastic flow of material. Part I deals with recent work on the behavior of ideal fiber-reinforced beams, higher modal response of beams, the influence of transverse shear and rotatory inertia, approximate meth-

ods of analysis, rapidly heated structures, fluid-structure interaction, and dynamic plastic buckling. Part II contains a discussion of a few numerical studies on the dynamic plastic response of structures and some miscellaneous comments and concluding remarks.

79-417

Guided Sound Transmission Through Layers

N. Romilly
Dept. of Appl. Mathematical Studies, Univ. of Leeds, Leeds LS2 9TJ, UK, Shock Vib. Dig., 10 (10), pp 3-7 (Oct 1978) 16 refs

Key Words: Reviews, Sound transmission, Panels

This paper reviews the analysis of sound transmission through single and double panels and thick layers. Mathematical methods are briefly described, as is recent experimental work. Suggestions for future research are presented.

MODAL ANALYSIS AND SYNTHESIS

(Also see No. 547)

79-418

Modal Superposition Method for Computationally Economical Nonlinear Structural Analysis

V.N. Shah, G.J. Bohm, and A.N. Nahavandi
Westinghouse Electric Corp., Pittsburgh, PA, ASME Paper No. 78-PVP-70

Key Words: Modal superposition method, Finite element technique, Seismic response

A modal superposition method for analyzing nonlinear structural dynamics problems involving impact between components is developed and evaluated. The finite element method is used to express the equations of motion with nonlinearities represented by pseudo force vector. Three test problems are solved to verify this method. This has demonstrated the applicability of this method to seismic analysis of large, complex structural systems.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 488, 498, 499)

79-419

Evaluation of Solution Schemes for Nonlinear Structures

D.P. Mondkar and G.H. Powell
Div. of Structural Engrg. and Structural Mech., Dept. of Civil Engrg., Univ. of California, Berkeley, CA 94720, Computers Struc., 9 (3), pp 223-236 (Sept 1978) 16 figs, 3 tables, 23 refs

Key Words: Computer programs, Finite element technique, Nonlinear systems

This paper investigates solution schemes of the type that can be implemented in general purpose computer codes for nonlinear finite element analysis. A very flexible solution strategy is discussed, in which a variety of solution schemes can be implemented by specifying the values of certain solution control parameters. A number of nonlinear structures with diverse nonlinear characteristics are selected and each is analyzed using different solution schemes.

79-420

FESAP -- Design Program for Static and Dynamic Structural Analysis

D.B. Van Fossen
Appl. Mechanics Section, Babcock and Wilcox Res. and Dev. Div., Alliance, OH 44601, Computers Struc., 9 (4), pp 371-376 (Oct 1978) 3 tables, 15 refs

Key Words: Computer programs, SAP (computer program), FESAP (computer program), Finite element technique

This paper documents the development of SAP (Structural Analysis Program) into a user-oriented program for linear dynamic and static analysis of large complex structures which is referred to as FESAP (Finite Element Structural Analysis Program). The paper describes companion computer programs which constitute a total design system for thermo-structural analysis. The total system includes mesh generation programs, a heat transfer program, the structural analysis program, batch and interactive graphic computer programs, and post-processors for the results of the heat transfer and structural analysis programs.

79-421

A Long-Term System Dynamic Response to a Sodium-Water Reaction in a Typical LMFBR Steam Generator Loop

T. Rauch
General Electric Co., Sunnyvale, CA, ASME Paper No. 78-PVP-66

Key Words: Computer programs, Dynamic response, Nuclear reactors

A newly developed computer code to simulate the dynamic response of a typical LMFBR steam generator loop to a sodium water reaction is presented. The code calculates sodium flows, loop pressures, sodium water reaction bubble pressure and volume, reaction product relief subsystem flows and clearing times, reaction product tank pressure and vent flow, and all dynamic pump characteristics.

79-422

Computer Code for Predicting the Dynamic Response of High Energy Piping, Pressure Vessels and Shell Structures Subjected to Transient Loads and Impacts

D. Meredith and E.A. Witmer

Massachusetts Inst. of Tech., Cambridge, MA, ASME Paper 78-PVP-33

Key Words: Computer programs, Piping systems, Pressure vessels, Shells, Nuclear reactor components, Dynamic response, Transient response

The MENTOR code was recently developed to provide an engineering basis for the prediction of the dynamic response of pipes, pressure vessels, or other shell-type structures subject to impact.

79-423

CURVBRG: A Program for Analysis of Curved I-Girder Bridges

G.H. Powell and D.P. Mondkar

Univ. of California, Berkeley, CA 94720, Computers Struc., 9 (3), pp 255-263 (Sept 1978) 8 figs, 1 table, 14 refs

Key Words: Computer programs, Bridges, Girders

A computer program for structural analysis of open girder (i.e., I-section) bridge super-structures is described. The program is based on a plane grid idealization, in which the effects of warping torsion are considered rationally, and in which structural components such as diaphragms and braced (truss type) cross frames are idealized by essentially exact procedures. The bridge may be of arbitrary shape in plan, the girders may be of variable cross section along their length, and changes in form of the structure as construction progresses are considered. Deflections, stress resultants and stresses are determined for static loads, support settlement effects and moving live loads. The structural idealization procedure and theory are explained, the features of a computer program developed to apply the method are described, and comparisons are made between the computed behavior and that observed in a model test.

79-424

Input Data Instructions - Simplified Documentation of the Computer Program ANSYS

P.Y. Chang

Hydronautics, Inc., Laurel, MD, Rept. No. MA-RD-920-78035A, 73 pp (Feb 1978)

PB-284 193/0GA

Key Words: Computer programs, Energy absorbers, Nuclear powered ships, Ship hulls, Collision research (ships), Finite element technique

A simplified version of the input instructions for the computer program ANSYS is presented for the non-linear elasto-plastic analysis of a ship collision protection barrier structure. All essential information necessary for the grillage model are summarized while eliminating the instructions for other types of the problems. A benchmark example is given for checking the computer program.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 417, 492, 495, 521, 535)

79-425

Noise in Textile Weaving Mills

A. Damongeot, R. Lataye, and P. Daniere

Institut National de Recherche et de Securite (NRS), Centre de Recherche de Nancy., Avenue de Bourgogne, 54500 Vandoeuvre, France, Noise Control Engr., 11 (2), pp 79-85 (Sept/Oct 1978) 8 figs, 3 tables, 6 refs

Key Words: Industrial facilities, Noise generation, Machinery noise, Textile looms

Everything possible must be done to protect workers from the harmful effects of noise. Any effort may prove inadequate unless the problem is dealt with when the mill is designed and new machinery acquired. In an investigation of noise in textile weaving mills, the authors examine the different types of looms and the characteristics of their use, as well as the nature of the mill site.

79-426

Reverberation in Town Streets

P. Steenackers, H. Myncke, and A. Cops

Laboratorium voor Akoestiek en Warmtegeleiding K.U. Leuven, Belgium, Acustica, 40 (2), pp 115-119 (June 1978) 8 figs, 1 table, 2 refs

Key Words: Traffic noise, Urban noise

An accurate prediction method for traffic noise levels in town streets, requires some knowledge about the reverberant sound field which is caused by the multiple reflections between flanking houses and buildings. The amount of reverberation depends mainly on the street width and on the absorption and diffusion coefficients of the facades. How the coefficients can be evaluated by means of a simple reverberation measurement combined with a correct interpretation of the sound decay curves is shown. The influence of the street reverberation on the sound level produced during the passage of a single vehicle was calculated and compared with measurements.

79-427

A Simplified Approach to the Mechanics of Acoustical Wave Propagation Applicable to the Problems of Radiation Pressure. Part I: On the Theory of Longitudinal Wave Propagation

M. Stapper

Dept. of Electrical Engrg., Eindhoven Univ. of Tech., The Netherlands, Acustica, 39 (2), pp 105-110 (Jan 1978) 2 tables, 7 refs

Key Words: Sound waves, Wave propagation

The concepts of continuum mechanics are applied to the propagation of a plane, longitudinal, simple, acoustic wave of finite amplitude in an arbitrary medium. A relationship is found between the characteristic and the equation of state of the sound conducting medium. This relationship holds for any physically existing medium. The equation of state is defined of a linear medium, i.e., a medium propagating without any distortion. This medium will be called isomorphium henceforth.

79-428

A Simplified Approach to the Mechanics of Acoustical Wave Propagation Applicable to the Problems of Radiation Pressure. Part II: The Application to Rayleigh and Langevin Radiation Pressure

M. Stapper

Dept. of Electrical Engrg. Eindhoven Univ. of Tech., The Netherlands, Acustica, 39 (2), pp 111-116 (Jan 1978) 3 figs, 1 table, 12 refs

Key Words: Sound waves, Wave propagation

The formulae derived in Part I of this paper are applied to Rayleigh and Langevin pressures. By doing this the magnitude of both pressures can be calculated.

RANDOM

79-429

Structural Reliability Under Combined Random Load Sequences

R. Rackwitz and B. Fiessler

Institut f. Massivbau, Technical Univeristy of Munich, Munich, West Germany, Computers Struc., 9 (5), pp 489-494 (Nov 1978) 4 figs, 2 tables, 7 refs

Key Words: Reliability, Random excitation, Random response, Structural elements

An algorithm for the calculation of structural reliability under combined loading is formulated. Loads or any other actions upon structures are modeled as independent random sequences. The relevant limit state criterion is pointwise approximated by a tangent hyperplane. The method is illustrated for a section of a wall without tensile strength loaded by a bending moment and a normal force.

79-430

Non-Stationary Random Vibration of a Linear Structure

P.-T.D. Spanos

Dept. of Aerospace Engrg. and Engrg. Mechanics, The Univ. of Texas at Austin, TX 78712, Intl. J. Solids Struc., 14 (10), pp 861-867 (1978) 4 figs, 14 refs

Key Words: Random vibration, Linear systems, Damped structures, Probability theory

The non-stationary random vibration of a lightly damped linear structure subjected to white noise is considered. It is shown that the probability density function of the amplitude of the structural response can be approximated by a Rayleigh distribution. Analytical formulae for the time dependent statistics of the amplitude are presented. The analytical results are compared with data obtained by a numerical simulation.

79-431

Nondeterministic Analysis of a Four-Wheeled Model Vehicle Traversing a Simulated Random Terrain

M.L. Chu and G.R. Doyle
The Univ. of Akron, OH, SAE Paper No. 780789, 12 pp, 7 figs, 24 refs

Key Words: *Ground vehicles, Random excitation, Simulation*

An experiment was performed with a four-wheeled model vehicle with an independent suspension system to increase confidence in the reliability and accuracy of the linear random vibration theory in predicting vehicular behavior. The vehicle has three degrees of freedom -- vertical translation, pitch, and roll – and was made to traverse at different speeds, a simulated road bed with randomly distributed surface roughness. Using linear random vibration theory, equations giving the power spectral density of each degree of freedom about the center of gravity of the vehicle were derived as a function of the power spectral density of the vertical displacement of the four wheels. Utilizing both numerical and experimental techniques, a direct comparison is made between theoretical predictions and experimental results.

79-432
Stick-Slip Motion and Surface Deformation
K. Ohara
Faculty of Textile Science and Tech., Shinshu Univ., Tokida, Ueda 386, Japan, Wear, 50, pp 333-342 (1978) 9 figs, 2 refs

Key Words: *Stick-slip response, Interferometers*

The relation between stick-slip motion and surface deformation in the frictional contact of polymer films is studied by multiple-beam interferometry.

SEISMIC

(Also see Nos. 411, 412, 497, 515, 516, 517, 519, 524, 537)

79-433
Seismic Structural Response Analyses of Steam Generators and Their Supporting Structures of a 1200 MW and a 600 MW Power Plant
M.I. Baig
Ph.D. Thesis, Purdue Univ., 262 pp (1978)
UM 7821411

Key Words: Seismic response, Steam turbines, Finite element technique, Natural frequencies, Mode shapes, Torsional vibration

The seismic response studies of the steam generators and their supporting structures of a 1200 MW and a 600 MW fossil fuel steam generating plants have been carried out using finite element models. The seismic response analyses of the two systems have been carried out in two parts. The first part involves the determination of fundamental frequencies of free vibration and the associated mode shapes. The second part involves the determination of modal responses of structural members stresses due to El Centro earthquake of May 18, 1940.

79-434
Stochastic Characterization of Earthquakes Through Their Response Spectrum
M.K. Kaul
Nuclear Services Corp., Campbell, CA, Intl. J. Earthquake Engrg. Struc. Dynam., 6 (5), pp 497-509 (Sept/Oct 1978) 7 figs, 17 refs

Key Words: Earthquakes, Seismic response spectra, Spectral energy distribution techniques

If earthquakes are modeled by a stochastic process, it is possible to interpret the associated response spectrum in terms of the statistics of extreme values of oscillator response to the process. For a stationary earthquake model this interpretation leads to a relationship between the power spectral density function of the process and the response spectrum. This relationship is examined and forms the basis for two methods to obtain the power spectrum of the earthquake process from its response spectrum. One method is approximate but leads to an explicit representation of the power spectral density function in terms of the response spectrum. The other method is exact wherein an iterative scheme for the solution of the problem is established.

79-435
Determination of Earthquake Loads on Structures - Research and Development Required
J.P. Lee
Brown & Root, Inc., P.O. Box 3, Houston, TX 77001, Nucl. Engr. Des., 50 (1), pp 57-61 (1978) 4 figs, 1 table, 14 refs

Key Words: Seismic excitation, Mathematical models, Simulation, Beams, Modal analysis

This paper discusses the research and development work required in three aspects of seismic analysis, i.e., modal combination criteria in the response spectrum analysis, the techniques in modeling and simulating structures, systems and components, and the determination of dynamic lateral earth pressure during an earthquake. In the seismic analysis of structures, the lumped mass method is commonly

used. For this method, the thin wall beam theory approach and the rigidity approach used in determining the effective shear areas and the distributions of translational shears are discussed. In the analysis of structures, either the time history or response spectrum method is used. When the response spectrum modal analysis method is used, the exact phase angle relation among maximum modal responses is not defined; therefore, a logical combination criterion must be established. The criterion for closely spaced modal responses to obtain system response is also mentioned. Finally, the significantly different lateral earth pressures on basement walls of embedded structures obtained using the Mononobe-Okabe method and the finite element method are also discussed.

SHOCK

(Also see Nos. 453, 510)

79-436

Critical Loads for Reinforced Concrete Bunkers

A.L. Florence

Sri International, Menlo Park, CA, Rept. No. DNA-4469F, AD-E300 292, 71 pp (Nov 1977)

AD-A058 300/5GA

Key Words: Underground structures, Protective shelters, Reinforced concrete, Nuclear explosion effects, Air blast

The Defense Nuclear Agency is conducting a program to obtain the failure loads of shallow-buried bunkers subjected to air blast waves acting on the ground surface. The blast waves of interest are those from a nearby nuclear weapon of 1-kton yield detonated on or above the ground surface. A simple conceptual framework for interpreting experimental and theoretical load-damage results is described. The framework consists of a pressure-impulse characterization of critical loads for the bunkers.

79-437

Oscillating Airfoils: I. Wedges of Arbitrary Thickness in Supersonic and Hypersonic Flow

R.M. Barron

Univ. of Windsor, Windsor, Ontario, Canada, AIAA J., 16 (10), pp 1076-1083 (Oct 1978) 11 refs

Key Words: Airfoils, Perturbation theory, Shock wave propagation

Equations are obtained by a perturbation method for straight and curved airfoils with attached shocks in supersonic and hypersonic flows and undergoing small harmonic oscillations. The mode shape of the oscillation is arbitrary and hence may be used to describe rigid body motions as well as elastic deformations of the body surface. The wedge problem is solved for small frequency and an exact expression for the pressure distribution is obtained as a function of the mode of oscillation. The analysis presented can be easily modified to treat the case of arbitrary two-dimensional body shapes by developing an unsteady Newtonian flow theory.

79-438

Weak Shock Propagation in Liquid-Filled Tubes

R.T. Smith, L. Bjorno, and R.W.B. Stephens

Imperial College, Univ. of London, London SW1, UK, Acustica, 39 (2), pp 123-129 (Jan 1978) 2 figs, 26 refs

Key Words: Tubes, Fluid-filled containers, Shock wave propagation

The most essential theoretical and experimental works related to the propagation of weak shock waves, i.e., sawtooth waves, N-waves and single shock pulses, in fluid-filled tubes are critically reviewed and simple theoretical expressions comprising shock front losses as well as wall losses are derived for weak shock propagation in fluid-filled, rigid-walled tubes. Pressure-time courses of electrodynamically generated weak shock waves propagating axially along a liquid-filled, thick-walled steel tube are measured.

PHENOMENOLOGY

COMPOSITE

(See No. 414)

DAMPING

(Also see No. 402)

79-439

Rotary Damping Helps Performance

Product Engr. (NY), 49 (10), pp 50-51 (Oct 1978) 1 fig

Key Words: Vibration damping, Rotors (machine elements)

The text explains how damping, whether it is electromagnetic, mechanical, viscous or hydrodynamic, improves motor and drive performance. Available types of damping devices are illustrated.

FLUID

(Also see Nos. 491, 508)

79-440

Fluid-Structure Dynamic Interaction and Wave Forces. An Introduction to Numerical Treatment

O.C. Zienkiewicz and P. Bettess

Dept. of Civil Engrg., Univ. College Swansea, Swansea, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 1-16 (1978) 7 figs, 26 refs

Key Words: Interaction: structure-fluid

The paper presents an introduction to two general approaches used in the solution of coupled structures and fluid systems in which effects of large scale flow are excluded. In the first approach, the Lagrangian, the fluid is simply treated as a solid with a negligible shear modulus. In the second method, Eulerian, a single pressure variable is used in the fluid. The numerical problems posed, discretization methods used and possible simplifications are discussed.

79-441

Staggered Solution Procedures for Doubly Asymptotic Fluid-Structure Interaction Analysis

K.C. Park, C.A. Felippa, and J.A. DeRuntz

Palo Alto Res. Lab., Lockheed Missiles and Space Co., Inc., Palo Alto, CA, Rept. No. LMSC/D624324, DNA-4525F, AD-E300 309, 49 pp (Feb 28, 1978) AD-A058 305/4GA

Key Words: Interaction: fluid-structure

This report examines direct time integration techniques for the transient response analysis of fluid-structure interaction problems treated with the doubly asymptotic approximation. Efficient solution of the equations of motion is achieved by a modular computer implementation in which separate fluid and structure analyzers are interfaced through extrapolation of the coupling terms.

79-442

Radiation and Scattering From an Arbitrary Elastic Structure Using Consistent Fluid Structure Formulation

J.S. Patel

Naval Underwater Systems Center, New London, CT 06320, Computers Struc., 9 (3), pp 287-291 (Sept 1978) 5 figs, 12 refs

Key Words: Harmonic response, Interaction: structure-fluid, Computer programs

The harmonic vibrational response and the resulting acoustic radiation from an aribtrary elastic structure immersed in an infinite inviscid fluid are formulated. Basic functions given by a cubic polynomial of the local coordinates are often used for the inertial and elastic formulation of the surface finite elements. To use the same basis functions for pressure and velocity variations on the finite surface area, the surface Helmholtz integral and its directional derivative are employed. An arbitrary, complex axisymmetric structure has been analyzed using the computer program FIST.

79-443

Acoustic Radiation and Scattering from Elastic Structures

D.T. Wilton

Admiralty Underwater Weapons Establishment, Portland, Dorset, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 123-138 (1978) 7 figs, 43 refs

Key Words: Interaction: structure-fluid, Acoustic scattering, Acoustic waves, Finite element technique

This paper presents a numerical technique for the linear dynamic analysis of a finite elastic structure immersed in an infinite homogeneous acoustic medium. It is required to determine the vibrational motion of the structure and also the associated acoustic field in the fluid, when the structure is either subjected to internal applied forces or is acting as a scatterer of an incident acoustic wave. A finite element analysis of the structure is matched at the structure-fluid interface with an integral equation representation of the exterior acoustic field, leading to a coupled system of equations which may be cast in either acoustic or structural form. The former approach is preferred, for which numerical results are presented when the method is applied to plane wave scattering by thick and thin elastic spherical shells.

79-444

An Efficient Method of Fluid-Structure Coupling in the Dynamic Analysis of Structures

R. Dungar

Dept. of Civil Engrg., Univ. of Bristol, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 93-107 (1978) 6 figs, 2 tables, 11 refs

Key Words: Interaction: structure-fluid, Seismic excitation, Dams, Off-shore structures, Finite element technique, Computer programs

A method of fluid-structure connection is presented for solutions which mainly involve the calculation of the dy-

namic response of structures by using the method of modal analysis. This connection method is based upon finite element structural and fluid representation and is efficiently employed when used with the inverse iteration procedure for eigenvalue, eigenvector evaluation. The inverse iteration procedure is described in conjunction with the connection method. Also a method of non-linear structural analysis and a method of frequency domain analysis are discussed with reference to the presented fluid-structure connection procedure. Applications are considered for both model and prototype situations. Efficient use of the mini computer for solving dynamic problems by the proposed method is also considered.

79-445
A Numerical Determination of the Entrained Water in Ship Vibrations
P. Orsero and J.L. Armand
Institut de Recherches de la Construction Navale, Paris, France, Intl. J. Numer. Methods Engr., 13 (1), pp 35-48 (1978) 6 figs, 4 tables, 39 refs

Key Words: Ships, Hydrodynamic excitation, Fluid induced excitation, Finite element technique

The hydrodynamic mass matrix for a vibrating ship is evaluated using a three-dimensional finite element discretization of the surrounding water. For the important case of vertical vibrations of the ship, values of the added masses obtained in this way are compared with those given by the conventional semi-empirical formulas currently in use in the shipbuilding industry. A numerical example is presented.

79-446
Aeroelastic Problems Outside Aeronautics and Astronautics
H.G. Natke, editor
Curt-Risch-Inst. f. Schwingungs- u. Messkunde, T.U. Hannover, Proc., Mtg. held at Tech. Univ. of Hannover, Federal Republic of Germany, Rept. No. CRI-K1/78, 616 pp (Mar 2-3, 1978)

Key Words: Aeroelasticity, Dynamic structural analysis, Proceedings

The papers deal with structural, fluid mechanical, numerical and computer problems, applications, and regulations in civil engineering problems. Individual papers dealing with shock and vibration are listed separately.

79-447
Synthesis of Aerodynamic Transfer Functions for Elastic Flight Vehicles
J.M. Ii
The Boeing Co., Seattle, WA, J. Aircraft, 15 (11), pp 777-785 (Nov 1978) 14 figs, 4 tables, 16 refs

Key Words: Flight vehicles, Flutter, Aerodynamic characteristics

A method of generating the reasonable approximations to aerodynamic transfer functions on general configurations of elastic wings or wing-body combinations is presented. The transfer functions are specified by asymptotic expansions in which either the polynomial or rational function approximation is applied. Procedures are described for incorporating a variety of quantitative and qualitative information concerning the unsteady aerodynamic behavior in both subsonic and supersonic flow regimes. Two types of power series approximations, power series with real coefficients and the other with complex coefficients, are applied.

79-448
Aerodynamic Forces on Finite Wings in Oscillatory Flow: An Experimental Study
M.H. Patel
University College of London, London, UK, AIAA J., 16 (11), pp 1175-1188 (Nov 1978) 17 figs, 11 refs

Key Words: Aircraft wings, Aerodynamic loads, Oscillation

Aerodynamic lift and pitching moment measurements on finite wings in oscillating vertical gusts of varying frequency parameter and gust amplitude are described. A set of six conventional wings with varying aspect ratio, sweep angle, and taper are tested. The experimental results are compared with a lifting surface theory for two of the test planforms. The effect on the aerodynamic forces of allowing free transition on the wing surfaces is also investigated.

SOIL

79-449
Non-Linear Seismic Response and Liquefaction
O.C. Zienkiewicz, C.T. Chang, and E. Hinton
Dept. of Civil Engrg., Univ. College of Swansea, UK, Intl. J. Numer. Anal. Methods Geomech., 2 (4), pp 381-404 (Oct-Dec 1978) 11 figs, 34 refs

Key Words: Seismic response, Soils, Nonlinear theories

.e essential cause of the growth of pore pressure during cyclic loading is identified as an autogenous shrinkage or densification of the solid phase of the soil and this is related to a strain path parameter. This shrinkage coupled with an elasto-plastic behavior of the soil skeleton is introduced and allows a full non-linear dynamic analysis to be conducted up to the point of structural failure for any earthquake input. Explicit time marching procedures are used. The procedure outlined is applicable to all problems of complex geometry and for conditions of undrained or partially drained behavior at a moderate computational cost.

VISCOELASTIC

79-450
Effect of Pulse-Width on the Measurement of the Ultrasonic Shear Absorption in Viscous Liquids
T.H. Hulusi
Dept. of Chemistry, Univ. of Essex, Colchester, Essex, C04 3SQ, UK, Acustica, 40 (4), pp 269-271 (Aug 1978) 1 table, 8 refs

Key Words: Shear vibration, Viscoelastic damping, Measurement techniques

The amplitude decay of pulses of shear mechanical oscillation resulting from the attenuation by a viscoelastic liquid is investigated for varying pulse-widths. It is shown that significant corrections must be applied to the simple exponential decay, normally associated with the measurement of the absorption coefficient.

EXPERIMENTATION

DIAGNOSTICS
(Also see No. 456)

79-451
Helicopter Bearing Failure Detection Utilizing Shock Pulse Techniques
J.A. George, T.C. Mayer, H.W. Sutphin, and J.T. Harrington
Parks College of St. Louis Univ., Cahokia, IL, Rept. No. USAAVRADCOM-TR-78-6, 478 pp (Sept 20, 1977)
AD-A057 308/9GA

Key Words: Diagnostic instrumentation, Helicopters, Bearings, Shock pulse method

The shock pulse technique works on the principle that a discrete fault, such as a pit or a spall, causes repetitive impacts of short duration. These impacts cause shock waves to propagate through the bearing structure causing a pulse displacement input to an accelerometer suitably attached to the bearing structure.

EQUIPMENT

79-452
A Composite Grip Design for Elimination of Extraneous Noise During Acoustic Emission Testing
W.E. Wood and D.D. Dilipkumar
Dept. of Materials Science, Oregon Graduate Center, Beaverton, OR 97005, J. Test Eval., 6 (6), pp 369-370 (Nov 1978) 3 figs, 6 refs

Key Words: Noise reduction, Test equipment

A major problem in acoustic emission analysis during dynamic loading – the noise generated by the test system itself – is discussed. A composite grip assembly, designed on the principle of rapid attenuation of sound waves when they pass through multiple interfaces, reduces the background noise by almost two orders of magnitude. This allows a maximum amount of information to be obtained through acoustic emission analysis.

FACILITIES

79-453
Airblast Simulator Design
Civil Nuclear Systems Corp., Albuquerque, NM, Rept. No. AFWL-TR-77-106, 154 pp (July 1978)
AD-A057 787/4GA

Key Words: Shock tests, Test facilities, Nuclear explosion simulation

A study was undertaken to identify structural and simulator concepts for use in the development of designs for low-cost disposable airblast simulator facilities. The Dynamic Airblast Simulator (DABS), an explosively-driven shock tube, and the High Explosive Simulation Technique (HEST), an earth-covered, explosive cavity are described. For the DABS, alternative construction concepts, including parabolic arches, cable suspension systems, concrete box girders, long-span steel joists, composite deck system, aircraft shelter arches

and circular concrete arches are evaluated for construction and cost feasibility. High pressure HEST facility concepts and the use of HEST for testing above-ground structures are evaluated. The various airblast simulator concepts are compared and rated relative to one another.

INSTRUMENTATION

79-454

Some Research Needs for Improved Seismic Qualifications Tests of Electrical and Mechanical Equipment

R.L. Bessey and D.D. Kana

Southwest Research Inst., 6220 Culebra Rd., San Antonio, TX 78284, Nucl. Engr. Des., 50 (1), pp 71-82 (1978) 11 figs, 3 tables, 18 refs

Key Words: Instrumentation, Seismic response, Simulation

There is a wide variety of methods of seismic simulation for qualifications tests for components to be used in nuclear power plants. This paper poses some questions with regard to the relationships among these methods of seismic simulation, the influence of laboratory seismic simulators required to produce the test seismic environment, and the way one demonstrates component functionality during a qualification test.

TECHNIQUES

(Also see No. 450)

79-455

Underwater Inspection and Nondestructive Testing of Offshore Structures

R. Brackett

Office of Naval Res., London, UK, Rept. No. ONRL-R-2, 16 pp (June 14, 1978)

Key Words: Off-shore structures, Nondestructive testing

Regulations have been established by the governments of countries bordering the North Sea which require annual inspection of offshore structures. This has resulted in a much more intensive use of nondestructive testing (NDT) techniques for underwater inspection than currently exists in the United States. A review of the NDT techniques and equipment currently used in the North Sea area is presented and some of the research being conducted in the UK and Norway to improve the quality of underwater NDT inspection is discussed.

79-456

Acoustic Emission Testing

A.T. Green

Acoustic Emission Technology Corp., Test, 40 (3&4), pp 8-11, 13-19 (Oct/Nov 1978) 11 figs, 14 refs

Key Words: Acoustic techniques, Diagnostic techniques

After a general introduction to the acoustic emission phenomenon, acoustic emission testing techniques and their application in static proof testing, fatigue testing, static testing and requalification testing are discussed.

COMPONENTS

SHAFTS

79-457

The Rubbing of a Rotating Shaft Against an Elastically Mounted Stationary Object – Spiral Vibrations (Das Streifen einer rotierenden Welle an einem federnden Hindernis – Spiralschwingungen)

W. Kellenberger

Erlenstr. 12, CH-5430 Wettingen, Switzerland, Ing. Arch., 47 (4), pp 223-239 (1978)

Key Words: Shafts, Spiral vibrations

A study is presented of the rubbing of a high speed rotating shaft on an elastically mounted stationary object.

79-458

The Effect of Rotary Inertia and Shear Deformation on the Parametric Stability of Unsymmetric Shafts

M. Badlani, W. Kleinhenz, and C.C. Hsiao

FluiDyne Engrg. Corp., Minneapolis, MN 55422, Mech. Mach. Theory, 13 (5), pp 543-553 (1978) 2 figs, 15 refs

Key Words: Shafts, Rotors (machine elements), Rotatory inertia effects, Transverse shear deformation effects

A study of the stability of unsymmetrical shafts with unequal flexural rigidities in the principal directions running in unsymmetric bearings having fixed common principal planes is presented. Inertia and transverse shear deformation effects are included in the analysis.

79-459
On Vibration of Rotating Shafts
M. Badlani, W. Kleinhenz, and C.C. Hsiao
FluiDyne Engrg. Corp., Minneapolis, MN 55422, Mech. Mach. Theory, 13 (5), pp 555-564 (1978) 2 figs, 26 refs

Key Words: Shafts, Rotors (machine elements), Rotatory inertia effects, Transverse shear deformation effects

Some results on the vibration of elastic and viscoelastic rotating shafts are presented. The cases of the simply supported symmetric and the simply supported unsymmetric shafts are studied. The effects of rotatory inertia and transverse shear deformation are included in the analysis and it is seen that there are two types of instabilities: bending and shear, as compared to just the bending type given by the Euler-Bernoulli theory.

BEAMS, STRINGS, RODS, BARS

(Also see Nos. 413, 415, 496)

79-460
At-Sea Measurements of the Dynamic Response of a Single-Point Mooring during an Anchor-Last Deployment
D.J. Meggitt and D.B. Dillon
Civil Engrg. Lab (Navy), Port Hueneme, CA, Rept. No. CEL-TM-44-78-9, 126 pp (Mar 1978)
AD-A058 329/4GA

Key Words: Cables, Underwater structures

A major program to develop techniques for the static and dynamic analysis of oceanic cable structures is presented. An extensive series of experiments in both laboratory and prototype sizes was conducted to provide data for comparison to calculate results from numerical models of cable structures. The results of an at-sea measurement of the dynamic response of a 2,500-ft long single point mooring during an anchor-last deployment are presented. The experiment was a part of the Mooring Dynamics Experiment (MDE).

79-461
Optimal Design of Impulsively Loaded Plastic Beams for Asymmetric Mode Motions
U. Lepik and Z. Mroz
Univ. of Tartu, Tartu, Estonian SSR, USSR, Intl. J. Solids Struc., 14 (10), pp 841-850 (1978) 5 figs, 1 table, 3 refs

Key Words: Beams, Optimum design, Asymmetry

Optimal design of a rigid-plastic stepped beam is discussed assuming the mode form of motion. Such beam dimensions are sought for which a minimum of local or mean deflection is attained within designs of constant volume. An optimal design for asymmetric modes is determined and compared with a respective design for symmetric modes.

79-462
Active Feedback Control of a Beam Subjected to a Nonconservative Force
H. Horikawa, E.H. Dowell, and F.C. Moon
Dept. of Aerospace and Mech. Sciences, Princeton Univ., Princeton, NJ 08450, Intl. J. Solids Struc., 14 (10), pp 821-839 (1978) 18 figs, 15 refs

Key Words: Cantilever beams, Follower forces, Flutter, Aircraft wings

The possibility of controlling through feedback a thin cantilevered beam subjected to a nonconservative follower force is examined. A converging frequency flutter instability which occurs in this model is similar to classical bending-torsion flutter of an aircraft wing. Because of the similar nature of the instabilities, the beam under the follower force can be a useful vehicle for investigating the fundamental aspects of stabilization of wing flutter by feedback control. A modal approach is used for obtaining the mathematical model and control laws. A standard root locus technique for simple analytical models is also used to understand and explain the control of the beam. Experiments are carried out to verify the validity of this theoretical model. Good correlation is shown between theoretically and experimentally determined stability boundaries as well as for modal frequency and damping variation with follower force.

BEARINGS

(Also see No. 451)

79-463
Bearings for Vibrating Machinery – Operating Experience and Further Development
B. Trygg
SKF Gothenburg, Ball Bearing J., 197, pp 4-6 (Oct 1978) 5 figs

Key Words: Bearings, Vibrating structures

The new design of spherical roller beraing, intended especially for vibrating applications (which SKF introduced some years ago) has been successful. Experience shows that the

bearing performs well even under other operating conditions, e.g. high ambient temperatures and dirty surroundings. The internal design of the bearing has been further improved by reducing the cross-section of the centering ring and the mass of the cage.

79-464

Dynamic Characteristics of Gas-Lubricated Externally Pressurized Porous Bearings with Journal Rotation. II

N.S. Rao and B.C. Majumdar
Dept. of Mech. Engrg., Indian Inst. of Tech., Kharagpur, India, Wear, 50, pp 201-210 (1978) 5 figs, 2 tables, 2 refs

Key Words: Gas bearings, Porous materials, Stiffness coefficients, Damping coefficients

The dynamic tilt stiffness and damping coefficients of an externally pressurized porous gas bearing with journal rotation have been calculated theoretically. A periodic disturbance (angular displacement) about the transverse axis is imposed on the bearing and the dynamic pressure distribution is determined by small perturbations of the Reynolds equation. Nondimensional tilt stiffness and damping coefficients for various design conditions are calculated numerically using a digital computer and presented in the form of figures and tables.

79-465

Stiffness and Damping Characteristics of Hydrostatic Multirecess Oil Journal Bearings

M.K. Ghosh and B.C. Majumdar
Dept. of Mech. Engrg., Banaras Hindu Univ., Varanasi, India, Intl. J. Mach. Tool Des. Res., 18 (3), pp 139-151 (1978) 13 figs, 6 refs

Key Words: Journal bearings, Stiffness characteristics, Damping characteristics, Perturbation theory

A design and performance of hydrostatic multirecess oil journal bearings under dynamic condition is given. The theory is based on first order perturbation method. Effect of various design parameters on stiffness and damping is investigated.

79-466

Improving Sleeve Bearing Fatigue Life – A New Design Concept

W.A. Yahraus
Engine Parts Div., Gould, Inc., SAE Paper No. 780-782, 12 pp, 13 figs, 1 table, 6 refs

Key Words: Sleeve bearings, Fatigue life

Peak oil film pressure is cited as the parameter controlling the fatigue life of a sleeve bearing. Variables affecting peak film pressure, and the freedom to control them, are discussed. Bearing clearance is the variable most readily controllable, and has the greatest impact on film pressure.

BLADES

79-467

Soil Excavation Improvement from Bulldozer Blade Oscillation

J.M. Brown
Dept. of Mech. Engrg., Mississippi State Univ., SAE Paper No. 780776, 20 pp, 18 figs, 2 tables, 8 refs

Key Words: Agricultural machinery, Vibratory tools, Blades

Tests and analyses are presented on bulldozer blade oscillation configurations for improving dozing productivity. The purpose of oscillation is to decrease the ratio of tractive force to blade force. The oscillating blade mass, frequency, amplitude, and direction of motion for optimum performance are determined using an approximate theoretical analysis. The theoretical results are compared with experimental results obtained from the literature.

CYLINDERS

79-468

Hydrodynamic Coefficients of Some Heaving Cylinders of Arbitrary Shape

R.E.D. Bishop, W.G. Price, and P.K.Y. Tam
Dept. of Mech. Engrg., University College London, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 17-33 (1978) 8 figs, 23 refs

Key Words: Cylinders, Ships, Fluid-induced excitation, Hydrodynamic excitation, Conformal mapping

The fluid forces acting on a uniform cylinder with an infinitely long axis, heaving in the free surface of an infinite ideal fluid, are described in terms of its 'added mass' and 'damping coefficient'. The techniques of multipole expansion and multiparameter conformal transformation are adopted for such calculations and applied to shapes which cannot be

adequately represented by the conventional 'Lewis form fit'. The shapes referred to are both relevant to ship bows, one being a 'fine section' and the other a 'bulbous section'. The parameters which influence the accuracy of the solution are examined. Results for these two sections are computed and compared with results based on the 'Lewis form approximation' and the 'Frank's close fit method' which employs a singularity representation.

DUCTS

79-469

Sound Transmission Through Ducts

J.J. Schauer, E.P. Hoffman, and R.W. Guyton

School of Engrg., Dayton Univ., OH, Rept. No. UDSE-TR-78-03, AFAPL-TR-78-25, 164 pp (May 1978)

AD-A057 803/9GA

Key Words: Ducts, Sound transmission, Acoustic linings, Sound attenuation, Computer programs

Analytic studies describing the propagation of sound waves in acoustically lined ducts are covered. These ducts are typically found in quieted high bypass turbine engine nacelles. Fortran IV computer programs were written for a CDC 6600 computer to predict maximum exponential attenuation of a least naturally attenuated mode in rectangular, annular, and cylindrical ducts of either uniform or sheared flow. Additional programs were written to design optimum perforated plate liners.

79-470

Propagation of Waves in Cylindrical Hard-Walled Ducts with Generally Weak Undulations

A.H. Nayfeh and O.A. Kandil

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA, AIAA J., 16 (10), pp 1041-1045 (Oct 1978) 5 refs

Key Words: Ducts, Wave propagation

The method of multiple scales is utilized to analyze the wave propagation in cylindrical hard-walled ducts having weak undulations which need not be periodic. Results are presented for two and three interacting modes.

79-471

On Estimating the Sound Radiation of Large Radial Ventilators from Acoustic Measurements at a Model Test Stand (Eine Abschaetzung der Schallabstrahlung grosser Radialventilatoren aus Schallmessungen am Modell-Pruefstand)

M. Bartenwerfer

Inst. f. Turbulenzforschung, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Berlin, West Germany, Rept. No. ESA-TT-480; DLR-IB-257-77/2, 34 pp (Oct 1977)

(In German)

N78-29878

Key Words: Ducts, Ventilation, Sound transmission

An elementary description of noise passing through walls and openings leads to formulas approximating the noise radiation of a ventilator. From pressure levels measured in an exhaust channel of the test stand for the original or for a geometrically similar model, the A (DIN 45633) and the unweighted sound power level of the ventilator or the average pressure level at a shell surface is calculated.

GEARS

79-472

Analysis of Torsional Vibration of an Automotive Gearbox

T.A.H. Pixton and R. Ali

Ford Motor Co., Auto. Engr., 3 (4), pp 64-66 (Aug/Sept 1978) 5 figs, 4 tables, 10 refs

Key Words: Gearboxes, Automotive transmissions, Mathematical models, Torsional vibration

An investigation into the degree of complexity required in a mathematical model for the accurate prediction of torsional vibration characteristics of an automotive gearbox is presented.

PANELS

(See No. 496)

PIPES AND TUBES

(Also see Nos. 422, 438)

79-473

Seismic Analysis of Piping Systems on Rocking Foundation Mat

M.J. Yan
The Babcock & Wilcox Co., Lynchburg, VA, ASME Paper No. 78-PVP-40

Key Words: Spectrum analysis, Piping systems, Foundations, Interaction: structure-foundation, Computer programs

The response spectra analysis on piping systems (when both translational and rocking motions of the foundation mat are considered) is discussed. The current response spectra analytical technique should be modified if significant rocking of the foundation mat makes it necessary to consider the effects of the rocking motions on the piping systems. A modified response spectral technique is derived. Some brief numerical comparison between the present technique and the time-history analysis is given and discussed. The numerical solutions are obtained using the Babcock & Wilcox developed piping code STALUM, which has implemented the present technique.

79-474

Flexibility Analysis of Buried Pipe

E.C. Goodling, Jr.
Gilbert Associates, Inc., Reading, PA, ASME Paper No. 78-PVP-82

Key Words: Piping systems, Underground structures, Interaction: soil-structure

The process of performing a strength analysis for piping that is buried in soil is discussed. Beginning with the various geotechnic parameters which define the motion and forces at the soil/pipe interface and control the degree to which the pipe conforms to the soil motion (or nonmotion in a thermal expansion analysis), methods are developed to calculate axial forces and bending moments at points of interest in the piping. Equations for Code stresses are presented and their applicability reviewed briefly.

79-475

Response of Water-Filled Thin-Walled Pipes to Pressure Pulses: Experiments and Analysis

C.M. Romander, L.E. Schwer, and D.J. Cagliostro
Poulter Lab., SRI International, Menlo Park, CA, ASME Paper No. 78-PVP-53

Key Words: Pipes, Fluid-filled containers, Pulse excitation, Interaction: structure-fluid

Experiments are performed to verify modeling techniques used in fluid-structure interaction codes that predict the response of liquid-filled piping systems to strong pressure pulses. Attenuation of the pressure pulse and the strain and deformation along the pipes are measured. The experiments are modeled in WHAM, a two-dimensional, finite-element, compressible fluid-structure interaction code. The experimental and analytical results are discussed.

79-476

Comparison of ICEPEL Predictions with Single Elbow Flexible Piping System Experiment

M.T. A-Moneim and Y.W. Chang
Argonne National Lab., Argonne, IL, ASME Paper No. 78-PVP-55

Key Words: Piping systems, Pulse excitation

The ICEPEL Code for coupled hydrodynamic-structural response analysis of piping systems is used to analyze an experiment on the response of flexible piping systems to internal pressure pulses. The piping system consisted of two flexible Nickel-200 pipes connected in series through a 90-deg thick-walled stainless-steel elbow. The analytical results of pressure and circumferential strain histories are discussed and compared against the experimental data obtained by Stanford Research Institute.

79-477

Attenuation of Weak Pressure Waves in a Simple Piping Loop

D.W. Ploeger
SRI International, Menlo Park, CA, ASME Paper No. 78-PVP-61

Key Words: Piping systems, Pulse excitation

Experiments are conducted in which a well-characterized pressure pulse is generated in a flat, open rectangular loop of stainless-steel pipe filled with water. The objective is to determine the attenuation of the pressure pulse as it propagates through an elbow, as well as the effect of the location and stiffness of the pipe supports at the elbows on the attenuation. Three support locations and two support stiffnesses are examined.

79-478

Rational and Economical Multicomponent Seismic Design of Piping Systems

A.K. Gupta
IIT Research Inst., Chicago, IL, ASME Paper No. 78-PVP-84

Key Words: Piping systems, Seismic design

The seismic analysis of complex piping systems is carried out by the response spectrum method. The maximum probable responses are calculated as the square root of the sum of the squares (SRSS) of the responses obtained in various modes of vibration for the three components of earthquake. A coupling matrix is introduced in the case of modes with closely spaced frequencies.

79-479
Simplified Seismic Analysis Method for Small Pipes
B.K. Niyogi
Brown and Root, Inc., Houston, TX, ASME Paper No. 78-PVP-43

Key Words: Pipes (tubes), Seismic response

Seismic analysis of lower safety class and/or smaller size pipes by simplified methods is performed. Spacing of the seismic restraints is based upon the following criteria: stress criteria, deflection criteria, and frequency criteria. An outline of a procedure which is simple to use and at the same time very general, is given.

79-480
Dynamic Response of a High-Pressure Steam Pipe in a Fossil Fuel Power Plant
C.T. Sun, H. Lo, J.L. Bogdanoff, and Y.F. Chou
Purdue Univ., West Lafayette, IN, ASME Paper No. 78-PVP-75

Key Words: Piping systems, Pipes (tubes), Seismic response, Damping effects

The dynamic behavior of the high-pressure steam pipe in the fossil fuel power plant of Unit No. 3 of TVA at Paradise, Kentucky, is investigated. Both natural vibration and the dynamic response of the piping system subjected to a ground acceleration identical to that of the El Centro 1940 earthquake are studied. In the analysis, the pipe is assumed to be fixed at both ends in one case; in the other case, the upper end of the pipe is connected to a shear beam that represents the boiler frame structure. The effect of damping is also investigated.

79-481
Consideration of Local Piping Stiffness in Dynamic Analysis by Piping Systems with Nonlinear Restraints
E.J. Bracken
Combustion Engineering, Inc., Windsor, CT, ASME Paper No. 78-PVP-109

Key Words: Piping systems, Stiffness characteristics, Geometric effects, Dynamic structural analysis

This paper develops a technique, using an elastic-plastic finite element code, to determine the local stiffness characteristics of specific geometries. An example is presented which compares a typical piping/restraint system analysis with and without consideration of this stiffness.

PLATES AND SHELLS

(Also see No. 422)

79-482
Safety Margin of Containment of Structures Under Impulsive Loading
S.C.H. Lu
Lawrence Livermore Lab., Univ. of California, Livermore, CA, ASME Paper No. 78-PVP-68

Key Words: Containment structures, Cylindrical shells, Pulse excitation, Finite element technique

This paper is based on the results of a plane strain, large displacement, elastic-plastic, finite-element analysis of a thin cylindrical shell subjected to external pressure pulses. An analytical procedure is presented for estimating the ultimate load capacity of the thin shell structure and, subsequently, for quantifying the design margins of safety for the type of loads under consideration.

79-483
Finite Element Analysis of Air Pulse Wave Loaded Single Thrown Concrete Plates (Analys Med Finit Elementmetod av Luftstoetvaagsbelastade, Enkelspaenda Betongplattor)
L. Nilsson and I. Johansson
Chalmers Univ. of Tech., Goteborg, Sweden, Rept. No. FOA-C-2024-D4(A3), 72 pp (Nov 1977)
(In Swedish)
N78-29516

Key Words: Plates, Concrete, Pulse excitation, Finite element technique

A finite element method was developed for dynamic structural analysis. Earlier development was aimed mainly at linear problem analyses, but now even several nonlinearities can be considered. The method is potentially suited for analysis of air pulse wave loaded concrete constructions. A two-dimensional calculation model for analysis of reinforced concrete constructions under plane stress is presented. Results of the calculations are compared with experimental results.

79-484

Vibration of Skew Plates at Large Amplitudes Including Shear and Rotatory Inertia Effects

M. Sathyamoorthy
Dept. of Aeronautical Engrg., Indian Inst. of Tech., Madras 600 036, India, Intl. J. Solids Struc., 14 (10), pp 869-880 (1978) 13 figs, 10 refs

Key Words: Skew plates, Flexural vibration, Transverse shear deformation effects, Rotatory inertia effects

An approach to the large amplitude free, undamped flexural vibration of elastic, isotropic skew plates is developed with the aid of Hamilton's principle taking into consideration the effects of transverse shear and rotatory inertia. On the basis of an assumed vibration mode of the product form, the relationship between the amplitude and period is studied for skew plates of various aspect ratios and skew angles clamped along the boundaries.

79-485

Effect of Accelerometer Mass on the Flexural Motion of Plates

N. Chang, D.P. Billington, and D.A. Nagy
Dept. of Civil Engrg., Princeton Univ., Princeton, NJ 08540, Intl. J. Solids Struc., 14 (10), pp 851-860 (1978) 7 figs, 1 table, 17 refs

Key Words: Plates, Flexural vibration

When the flexural acceleration of a plate is measured by an accelerometer, the mass of the accelerometer tends to reduce the magnitude of the acceleration. This study establishes a simple analytical relation between the accelerometer mass and the corresponding reduction of acceleration. This has been done by studying an idealized diffraction problem for the plate flexural waves.

79-486

Effect of Geometric Nonlinearity on the Free Flexural Vibrations of Moderately Thick Rectangular Plates

K.K. Raju, G.V. Rao, and I.S. Raju
Structural Engrg. Div., Vikram Sarabhai Space Centre, Trivandrum-695022, India, Computers Struc., 9 (5), pp 441-444 (Nov 1978) 5 tables, 6 refs

Key Words: Rectangular plates, Flexural vibration, Geometric effects, Transverse shear deformation effects, Rotatory inertia effects

The effect of geometric nonlinearity on the free flexural vibrations of moderately thick rectangular plates is studied in this paper. Finite element formulation is employed to obtain the non-linear to linear period ratios for some rectangular plates. A conforming finite element of rectangular shape wherein the effects of shear deformation and rotatory inertia are included, is developed and used for the analysis. Results are presented for both simply supported and clamped boundary conditions.

79-487

The Damping of Plate Vibration by Interfacial Slip Between Layers

C.F. Beards and I.M.A. Imam
Imperial College of Science and Tech., Exhibition Rd., London SW7, UK, Intl. J. Mach. Tool Des. Res., 18 (3), pp 131-137 (1978) 7 figs, 16 refs

Key Words: Plates, Vibration damping

The damping in plate type structures can be significantly increased by using laminated plates correctly fastened to allow controlled interfacial slip during vibration. The clamping forces acting on a laminated plate to give maximum damping and minimum response amplitude have been investigated for the first mode of plate vibration. The optimum clamping force required for maximum damping has been found.

79-488

Computer Module for One Step Dynamic Response of an Axisymmetric or Plane Linear Elastic Thin Shell

G.L. Goudreau
Methods Development Group, Lawrence Livermore Lab., California Univ., Livermore, CA, Rept. No. UCID-17730, 17 pp (Feb 1978)
N78-29512

Key Words: Shells, Dynamic response, Computer programs

A computer subprogram is offered as a module for coupling an axisymmetric or plane linear elastic thin shell to two-dimensional fluid or solid continuum codes. Given the current geometry and particle velocities and new interface pressures, the subprogram computes the new geometry and particle velocities. The method is based upon the unconditionally stable Newmark or trapezoidal method of implicit time integration. The shell formulation is taken from the thin shell theory of Kraus with shear deformation. The finite element formulation utilizes piecewise linear expansions of membrane and transverse displacements as well as the rotation. Utilizing the one point quadrature of Hughes, the method is accurate in the thin shell limit.

79-489

Transient Response of Thin, Thick, or Sandwich Shells and Pressure Vessels Subjected to Transient Loads

D. Meredith and E.A. Witmer

Massachusetts Inst. of Tech., Cambridge, MA, ASME Paper No. 78-PVP-35

Key Words: Pressure vessels, Shells, Sandwich structures, Transient response, Finite difference theory

The governing equations for the arbitrarily-large-deflection elastic-plastic transient responses of variable thickness, multi-layer, multimaterial, thin hard/or soft-bonded or thick hard-bonded shells or pressure vessels are formulated. These equations are then cast into finite-difference form for numerical solution. The shell material is assumed to be initially isotropic and to exhibit elastic, strain-hardening, strain-rate sensitive, viscoelastic, and temperature-dependent behavior. The structure may be subjected to a variety of initial velocity distributions, impulsive loads, and transient mechanical and/or thermal loads. The transient response of a thin circular plate, a thick cylindrical panel, and a soft-bonded three-layered panel are presented and compared with solutions from alternative predictive techniques.

79-490

Nonlinear Flexural Oscillations of Orthotropic Shallow Spherical Shells

T.K. Varadan and K.A.V. Pandalai

Aeronautical Engrg. Dept., Indian Inst. of Tech., Madras 600036, India, Computers Struc., 9 (4), pp 417-425 (Oct 1978) 10 figs, 5 tables, 12 refs

Key Words: Spherical shells, Orthotropism, Flexural vibration

The effect of curvature and polar orthotropy on nonlinear dynamic behavior of a shallow spherical shell is investigated. Numerical solutions based on an assumed two-term modeshape for the axisymmetric, forced (uniform pressure) and free vibrations are obtained for different shell geometries and orthotropic material constants. The results, when specialized for the case of isotropic material, are in good agreement with those available in the literature. Based on a one-term modeshape solution, the values of the geometric parameter at which the transition from hardening to softening type of nonlinearity takes place and where the reversal of the softening trend occurs are obtained for different values of the orthotropic constants.

79-491

Oscillations of a Liquid in a Rotating Cylinder. Part I. Solid-Body Rotation

C.W. Kitchens, Jr., N. Gerber, and R. Sedney

Ballistics Res. Lab., Army Armament Res. and Dev. Command, Aberdeen Proving Ground, MD, Rept. No. ARBRL-TR-02081, AD-E430 078, 40 pp (June 1978)

AD-A057 759/3GA

Key Words: Cylindrical shells, Fluid-filled containers, Sloshing

For application to liquid-filled shell problems, the natural frequencies and decay rates of oscillations of liquids during spin-up in filled rotating cylinders are calculated. This part describes in detail the method of solution for the general case of spin-up, and presents results which check with experimental and previous theoretical data closely enough to confirm the reliability of the computational procedure.

79-492

Finite Element Analysis of the Noise Inside a Mechanically Excited Cylinder

M. Petyt and S.P. Lim

Inst. of Sound and Vibration Res., Univ. of Southampton, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 109-122 (1978) 4 figs, 4 tables, 25 refs

Key Words: Cylindrical shells, Finite element technique, Acoustic response

A finite element method is presented for predicting the coupled structural-acoustic response of a flexible cylinder, which contains an acoustic medium and is excited by mechanical forces. The cylinder is represented by an existing axisymmetric, cylindrical shell element. The acoustic space inside the cylinder is modeled using a new axisymmetric, acoustic ring element. The cross-section of the ring takes the form of an eight mode, isoparametric element. The coupled equations of motion for the cylinder and acoustic field are solved using modal analysis techniques. The numerical results obtained are compared with results from an experimental investigation which is also described.

79-493

Transient Response of Shells with Internally Attached Structures

D. Ranlet and F.L. DiMaggio

Weidlinger Associates, 110 E. 59th St., New York, NY 10022, Computers Struc., 9 (5), pp 475-481 (Nov 1978) 5 refs

Key Words: Shells, Submerged structures, Transient response

Equations of motion are derived for the transient response, to a shock wave, of a submerged shell with internal structures. A substructuring procedure, which does not require calculation of a system stiffness matrix, is employed to obtain these equations in a general manner for arbitrary internal structures approximated by finite elements.

79-494
Dynamic Buckling of Axisymmetric Spherical Caps with Initial Imperfections
R. Kao and N. Perrone
Dept. of Civil, Mech. and Environmental Engrg., The George Washington Univ., Washington, D.C. 20052, Computers Struc., 9 (5), pp 463-473 (Nov 1978) 14 figs, 2 tables, 18 refs

Key Words: *Shells, Caps (supports), Initial deformation effects, Dynamic buckling*

Dynamic buckling loads are obtained for axisymmetric spherical caps with initial imperfections. Two types of loading are considered, namely, step loading with infinite duration and right triangular pulse. Solutions of perfect spherical caps under step loading are in excellent agreement with previous findings. Results show that initial imperfections do indeed have the effect of reducing the buckling capacity for both dynamic and static responses, although they are affected in a different manner.

STRUCTURAL
(Also see Nos. 409, 410, 416, 517)

79-495
Prediction Methods for the Sound Transmission of Building Elements
B.H. Sharp
Wyle Labs/Wyle Research, 2361 Jefferson Davis Hwy., Suite 404, Arlington, VA 22202, Noise Control Engr., 11 (2), pp 53-63 (Sept/Oct 1978) 14 figs, 8 refs

Key Words: *Sound transmission loss, Prediction techniques, Structural members*

Existing techniques for predicting sound transmission loss generally provide unrealistic values for all but the simplest type of building elements. The author describes an improved prediction procedure and gives examples of its application.

79-496
Analysis of Cable Net-Panel Roof System
E.P. Foster and F.W. Beaufait
Univ. of Tennessee at Nashville, TN 37235, Computers Struc., 9 (5), pp 501-521 (Nov 1978) 12 figs, 4 refs

Key Words: *Cables, Panels, Roofs, Suspended structures, Computer programs*

The study presented in this paper deals with the analysis of a cable net roof system with precast panels which are prestressed to increase the stiffness of the system. A computer program was developed to analyze a cable net roof structure and an experimental investigation was carried out to verify the theoretical analysis performed by the computer program and to study the response of a cable net-panel system during the prestressing of the panels.

79-497
Applicability of Structural Wall Test Results to Seismic Design of Nuclear Facilities
H.G. Russell, R.G. Oesterle, A.E. Fiorato, and W.G. Corley
Portland Cement Assn., Old Orchard Rd., Skokie, IL 60076, Nucl. Engr. Des., 50 (1), pp 49-56 (1978) 5 figs, 35 refs

Key Words: Structural members, Walls, Reinforced concrete, Nuclear power plants, Earthquake resistant structures

A review of tests on earthquake-resistant reinforced concrete structural walls is presented. Laboratory tests of isolated walls and construction joints are discussed. Where appropriate, design recommendations are given.

SYSTEMS

ABSORBER
(Also see No. 424)

79-498
Simulation of Collision Model Tests
P.Y. Chang
Hydronautics, Inc., Laurel, MD, Rept. No. MA-RD-820-78036, 209 pp (Mar 1978)
PB-284 506/3GA

Key Words: Simulation, Energy absorption, Nuclear powered ships, Ship hulls, Collision research (ships), Mathematical models, Computer programs

The simulation of collision model tests of ships is presented in this report. The objective of this simulation is to validate the methods of analysis, the mathematical model, and the computer program for analysis and design of the collision protection barrier structures. The results are compared with those obtained from the collision model tests. (Portions of this document are not fully legible).

79-499

The Development and Validation of a Mathematical Model for the Design of Protection Barriers for Nuclear Powered Ships

P.Y. Chang

Hydronautics, Inc., Laurel, MD, Rept. No. MA-RD-920-78037, 130 pp (Mar 1978)

PB-284 174/0GA

Key Words: Mathematical models, Energy absorbers, Nuclear powered ships, Ship hulls, Computer programs, Finite element technique, Collision research (ships)

A mathematical model for the analysis and design of protection barrier structures is developed. The analysis procedure is based on the collapse theorems, i.e., the Upper Bound Theorem and the Lower Bound Theorem. The collision protection barrier is analyzed by a finite element program with capabilities of nonlinear and elastoplastic analysis. The results obtained from the mathematical model are compared with those obtained from the collision model tests.

79-500

Applications of Wave Diffraction Theory

R.G. Standing

National Maritime Inst., Feltham, Middlesex, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 49-72 (1978) 13 figs, 20 refs

Key Words: Moorings, Energy absorption, Water waves, Wave diffraction, Computer programs

A computer program, originally developed to predict wave loads on large-diameter fixed offshore structures, has been modified to compute added masses, damping coefficients and response motions of free-floating and moored rigid systems. It is now being extended to predict multi-degree-of-freedom responses of articulated structures, particularly wave energy absorbing devices. The structure is modeled by surface singularities (point sources) in potential flow. The boundary conditions, fluid and structure equations of motion are linearized. Engineering applications include the prediction of wave loads on a gravity platform, response motions of a moored barge, and comparisons with laboratory data on the mooring loads and response of a tethered buoyant platform, and on the wave loading, response and efficiency of two wave energy absorbing devices.

NOISE REDUCTION

79-501

Control of Hydraulic System Noise in a Military Vehicle

R.N. Baker

H.L. Blachford, Inc., SAE Paper No. 780758, 12 pp, 13 figs, 7 refs

Key Words: Hydraulic equipment, Noise control, Trucks, Military vehicles, Off-highway vehicles

Retrofit noise controls were developed to reduce the noise exposure of the operator of a large Army forklift truck. Various noise sources are studied and modified. The overall success of the program is determined by the reduction achievable in hydraulic system noise reaching the operator by airborne, fluid-borne and structure-borne paths. Practical retrofit modifications to reduce hydraulic system noise include component replacement, introduction of flexible fluid lines, vibration isolation and vibration damping.

79-502

Practical Methods for Reducing Hydraulic Noise

G.E. Maroney and J.D. Harris

Fluid Power Research Ctr., Oklahoma State Univ., OK, SAE Paper No. 780757, 12 pp, 7 figs, 3 tables, 13 refs

Key Words: Hydraulic equipment, Noise reduction, Off-highway vehicles

This paper discusses the control of hydraulic noise along the vibration and pressure ripple transmission paths. The basic theories of structureborne and fluidborne noise control are discussed. The examples include quantitative results.

79-503

Partial Enclosures Control Noise Exposure in a Sheet-Steel Manufacturing Plant

R.E. Manning and C.R. Listwak

United States Steel Corp., Monroeville, PA, S/V, Sound Vib., 12 (20), pp 12-19 (Oct 1978) 18 figs, 2 tables

Key Words: Enclosures, Noise reduction, Industrial facilities

The development and evaluation of partial acoustical enclosures, for noise control at specific locations in a sheet-steel plant, are described.

79-504
A Study of the Packaging of a Small Engine (1st Report. Relationship Between Vibration and Noise)
M. Fukuda, H. Izumi, and Y. Ushijima
Yamaguchi Univ., Ube, Japan, Bull. JSME, 21 (159), pp 1371-1377 (Sept 1978) 10 figs, 5 refs

Key Words: Enclosures, Engine noise, Noise reduction

Noise sources of an engine can be roughly classified into exhaust noise, suction noise and engine surface noise. This paper shows the relation between the noise and vibration of a package enclosing a small engine.

79-505
A Study of the Packaging of a Small Engine (2nd Report. Theoretical Investigation of the Sound Insulation Effect of Package)
M. Fukuda and K. Kido
Yamaguchi Univ., Ube, Japan, Bull. JSME, 21 (159), pp 1378-1384 (Sept 1978) 4 figs, 1 table, 4 refs

Key Words: Enclosures, Engine noise, Noise reduction

In this paper the sound attenuation effect of the package is analyzed theoretically for an enclosed engine, and theoretical equations are obtained for two cases where the dimension of package is very large compared with the wavelength of sound wave and where the dimension is very small compared with the wavelength. Theoretical analysis is performed regarding the sound transmission loss of various types of package walls and some interesting results are obtained.

79-506
EBC Noise Abatement Symposium - A Summary
Noise Control Vib. Isolation, 9 (8), pp 338-339 (Oct 1978)

Key Words: Noise reduction, Industrial facilities

The noise abatement symposium in the field of brewing and malting, held by the European Brewery Convention in Denmark, in November 1977, is summarized, The program was divided into three parts: noise and its influence on man; experiences with noise abatement in the brewing industry; and future methods and means in noise abatement.

ACTIVE ISOLATION

79-507
Active Controls Technology to Maximize Structural Efficiency
J.M. Hoy and J.M. Arnold
Boeing Commercial Airplane Co., Seattle, WA, In: CTOL Transport Technol., Langley Res. Center, NASA, pp 709-732 (1978)
N78-29053

Key Words: Active flutter control, Aircraft

The implication of the dependence on active controls technology during the design phase of transport structures is considered. Critical loading conditions are discussed along with probable ways of alleviating these loads. The significance of certain flutter suppression system criteria is examined.

AIRCRAFT

(Also see Nos. 447, 448, 462, 507, 529, 541)

79-508
Aerodynamic Characteristics of Fighter Configurations During Spin Entries and Developed Spins
E.L. Anglin
Langley Res. Center, NASA, Hampton, VA, J. Aircraft, 15 (11), pp 769-776 (Nov 1978) 14 figs, 1 table, 12 refs

Key Words: Aerodynamic characteristics, Aircraft

The NASA Langley Research Center is currently conducting a stall/spin research program to define fighter aerodynamics applicable during spin entries and developed spins and to develop analytical methods to use such measured aerodynamics for theoretically calculating these spin motions. Some static, forced-oscillation, and continuous rotation aerodynamic data have been measured for several current fighter models over a large post-stall angle-of-attack range. This paper discusses these aerodynamic data and illustrates both the extremely nonlinear dependence of such data on several variables and the correlation that exists between the three types of measured aerodynamics. The current analytical methods for using these aerodynamics to calculate spin entry and developed spin motions are discussed and correlated with experimentally obtained spins.

79-509
Probability that the Propagation of an Undetected Fatigue Crack Will Not Cause a Structural Failure
J.R. Gebman and P.C. Paris
Rand Corp., Santa Monica, CA, Rept. No. RAND/R-2238-RC, 80 pp (June 1978)
AD-A057 335/2GA

Key Words: Aircraft, Failure analysis, Crack propagation, Probability theory

This report presents a procedure for calculating the probability that an element has not failed, as a function of the crack propagation time and hence the crack's length. Computations with a desk calculator can yield reasonably accurate results. The report uses data that an aircraft manufacturer developed for the structural components/elements that currently limit the service life of an existing transport aircraft.

79-510
Blast and Thermal Effects of Multiple Nuclear Burst Exposure of Aircraft in a Base-Escape Mode
R.P. Yeghiayan, W.N. Lee, and J.P. Walsh
Kaman Avidyne, Burlington, MA, Rept. No. KA-TR-146, DNA-4481F, 77 pp (Oct 1977)
AD-A058 301/3GA

Key Words: Aircraft, Nuclear explosion effects

Analytical methods are employed to investigate the enhancement or attenuation of gust, overpressure, and thermal radiation effects due to multiple nuclear bursts in comparison with worst-case single burst exposure. The nuclear attack scenario assumes placement of the simultaneous nuclear bursts in a low-altitude planar hexagonal close-packed configuration to damage aircraft in a base-escape mode. Symmetry considerations are taken into account in investigating the possible aircraft position and flight path orientations.

79-511
Application of Optimization Technology to Wing/Store Flutter Prediction
R.R. Chipman and J.B. Malone
Grumman Aerospace Corp., Bethpage, NY, J. Aircraft, 15 (11), pp 786-792 (Nov 1978) 10 figs, 3 tables, 14 refs

Key Words: Wing stores, Flutter, Optimization, Steepest descent method

Gradient-directed numerical search techniques, using derivatives of flutter speed with respect to store parameters, are applied to the problem of determining critical flutter configurations for a wing with multiple external stores. The elementary steepest-descent method is first applied to demonstrate the feasibility of the overall approach; a more efficient and reliable algorithm (rank-one-correction) is later introduced to obtain a satisfactory search procedure. Applications to a two-and a four-variable problem are presented. The method offers a useful alternative to current practices and can reduce the potentially catastrophic possibility of "missing" critical store configurations.

79-512
Flutter Prevention Means for Aircraft Primary Flight Control Surfaces
K.A.B. Macdonald
Dept. of the Air Force, Washington, D.C., Rept. No. AD-D005 074/0, 10 pp (Apr 27, 1978)
PAT-APPL-900 621/GA

Key Words: Active flutter control, Aircraft, Flutter

An apparatus attached to the flight control surface designed to lock the surface in a fixed and generally neutral position when a hydraulic pressure failure occurs is described. A spring loaded hydraulic actuator is mounted in the fixed wing structure but has an arm with a locking roller extending into a wedge shaped recess in the adjacent movable control surface.

BIOENGINEERING

79-513
Determination of a Dynamic Model for Urethane Prosthetic Compounds
G.M. Smith, Y.C. Pao, and J.D. Fickes
Dept. of Engrg. Mechanics, Univ. of Nebraska, Lincoln, NB 68508, Exptl. Mech., 18 (10), pp 389-395 (Oct 1978) 12 figs, 1 table, 8 refs

Key Words: Bioengineering, Prosthetic compounds, Organs (biological), Periodic excitation, Mathematical models

A frequency-response testing technique for determining the dynamic behavior of urethane prosthetic compounds is discussed. Experimental preparation of strip specimens and test results are presented. Sinusoidal response data of the tested strips are compared with three computer synthesizers (viscoelastic, viscous and complex modulus) of the one-dimensional wave equation for deciding on a model which best represents the material and subsequently calculating the value of a dynamic loss factor. The closed form solutions

for the three mathematical models subject to sinusoidal boundary conditions are expressed in terms of functions which can be easily programmed for machine computation in FORTRAN IV language involving complex arguments.

BRIDGES

(Also see No. 423)

79-514

Vibration Studies and Tests of a Suspension Bridge

A.M. Abdel-Ghaffar

Dept. of Civil Engrg., California Inst. of Technology, Pasadena, CA, Intl. J. Earthquake Engr. Struc. Dynam., 6 (5), pp 473-496 (Sept-Oct 1978) 13 figs, 6 tables, 10 refs

Key Words: Suspension bridges, Natural frequencies, Traffic-induced vibrations

The natural frequencies of the San Pedro-Terminal Island Suspension Bridge were determined by measuring traffic-excited vertical vibrations with sensitive seismometers mounted at various locations on the bridge. The Fourier amplitude spectrum of the recorded vertical movements was computed and plotted. The measurements revealed a wide band of natural frequencies. The results for the vertical and torsional natural frequencies were correlated with the computed frequencies. The results of the field measurements showed reasonable agreement with the computed values.

BUILDING

79-515

Response Spectrum Techniques for Asymmetric Buildings

A. Rutenberg, T. Hsu, and W.K. Tso

Technion--Israel Inst. of Tech., Haifa, Israel, Intl. J. Earthquake Engr. Struc. Dynam., 6 (5), pp 427-435 (Sept/Oct 1978) 11 figs, 17 refs

Key Words: Buildings, Asymmetry, Sesimic response spectra, Torsional response

The effect of torsion on each lateral load resisting element of asymmetrical buildings in the context of the response spectrum technique is calculated. Methods of this calculation consist of: (i) obtaining the modal shear and torque on the building by the response spectrum technique; (ii) computing the total modal shear forces on each frame by resolving the modal shear and torque on the building according to principles of structural mechanics; the shears on each frame due to the lateral load effect and torsional effect are combined algebraically; and (iii) obtaining the total shear force on each frame by combining the total modal shears on that frame in a root sum square manner.

79-516

Dynamic Response of Tipping Core Buildings

J.W. Meek

Aug. Prien Construction Co., Hamburg, Germany, Intl. J. Earthquake Engr. Struc. Dynam., 6 (5), pp 437-454 (Sept/Oct 1978) 12 figs, 12 refs

Key Words: Multistory buildings, Core-containing structures, Earthquake response

A method is described for including the effects of tipping in the analysis of multistory core-braced structures. Curves are presented which summarize the maximum response to both pulse and earthquake excitations; these data are elucidated via a typical design example.

79-517

Highlights of an Experimental Investigation of the Seismic Performance of Structural Walls

A.E. Fiorato, R.G. Oesterle, P.H. Kaar, G.B. Barney, and B.G. Rabbat

Construction Technology Labs., Portland Cement Assn., Skokie, IL, Rept. No. NSF/RA-760851, 13 pp (Mar 30, 1976)

PB-284 678/0GA

Key Words: Buildings, Walls, Earthquake resistant structures, Reinforced concrete

Design criteria are developed for reinforced concrete structural walls used as lateral bracing in earthquake-resistant buildings. Primary items of interest include the ductility, energy dissipation capacity, and strength of structural walls. This paper describes the highlights of the experimental investigation which consists of four parts: isolated walls are subjected to reversing in-plane loads; structural wall systems are subjected to proof tests of coupled walls and frame-wall structures; an investigation is conducted of the stress versus strain characteristics of confined concrete; and an investigation is conducted of the behavior of coupling beams subjected to reversed loading.

79-518

On Inelastic Response Spectra for Aseismic Design

S.S.P. Lai, J.M. Biggs, and E.H. Vanmarcke

Constructed Facilities Div., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. R78-18, MIT-CE-R78-18, 155 pp (July 1978)
PB-284 507/1GA

Key Words: Buildings, Framed structures, Earthquake resistant structures, Computer programs

The sources of variability in inelastic response spectra, namely, strong ground motion duration, ductility level, and viscous damping ratio, are investigated. By comparing the 'inelastic response ratios,' new inelastic response spectra are proposed. Based upon simulation studies, semi-empirical modifications to an elasto-plastic random vibration model are suggested. The resulting probabilistic predictions of the inelastic response are compatible with those obtained by time history analysis.

79-519
Tentative Provisions for the Development of Seismic Regulations for Buildings
Center for Bldg. Tech., National Engrg. Lab. (NBS), Washington, D.C., Rept. No. NBS-SP-510, NSF-78-8, 549 pp (June 1978)
Sponsored by the National Science Foundation
PB-284 140/1GA

Key Words: Buildings, Earthquake resistant structures, Standards and codes

This document contains tentative seismic design provisions for use in the development of seismic code regulations for design and construction of buildings. The provisions are comprehensive in nature and deal with earthquake resistant design of the structural system, architectural and non-structural elements and mechanical-electrical systems in buildings. Both new and existing buildings are included. They embody several new concepts which are significant departures from existing seismic design provisions.

CONSTRUCTION

79-520
The Richier A625 Road Roller – Combining Major Components of a Vibrating Road Roller and a Wheel Loader to Create a New Machine
R.E. Dannan and J.H. Perrin
Ford Tractor Operations, Ford Motor Co., SAE Paper No. 780738, 8 pp, 7 figs, 1 table

Key Words: Construction equipment, Vibratory techniques

Studies conducted in Europe indicated a need for a vibrating road roller in the 10 ton size. Combining major components of an existing wheel loader and an existing vibrating roller provides a vehicle configuration matched to the customer need for the least development and tooling cost.

HELICOPTERS
(See Nos. 540, 548)

HUMAN
(Also see No. 408)

79-521
Commercial Airport Operations and Community Noise Criteria
J.E. Mabry and B.M.S. Sullivan
Man-Acoustics and Noise, Inc., Seattle, WA, Rept. No. MAN-1031, FAA-RD-78-36, 77 pp (Mar 1978)
AD-A057 451/7GA

Key Words: Aircraft noise, Human response

This study program involved response of 48 persons to seven different simulated commercial airport noise environments. Each exposure period was of 1-½ hours duration and subjects experienced and rated eight of these 1-½ hour noise exposure periods. The test environments simulated a conventional living room environment. Number of aircraft noise intrusions per exposure period ranged from 6 to 18 flyovers and indoor Leq (dBA) levels ranged from 38.9 to 52.1 dB.

ISOLATION

79-522
The Isolation of Vibration on Off-Shore Platforms
Noise Control Vib. Isolation, 9 (8), p 337 (Oct 1978) 2 figs

Key Words: Off-shore structures, Vibration isolation

The inclusion of isolation bearings for the living quarters on off-shore platforms in the North Sea, using structural anti-vibration bearings is described. The bearings are of vulcanized laminate construction comprising reinforcement plies of high strength synthetic fabric bonded to an elastomeric compound, modified by the inclusion of cellular particles. The face plies are of a slightly different formulation to facilitate bonding to structural surfaces. Due to severe operating conditions, exposed edges of the bearings are

double coated with hypalon lacquer for additional protection.

79-523

Mechanical Isolation of Hydraulic Noise Sources

S.J. Skaistis

Sperry Vickers

SAE Paper No. 780759, 12 pp, 10 figs, 2 tables, 4 refs

Key Words: Hydraulic equipment, Pumps, Off-highway vehicles, Vibration isolators

The vibration characteristics of hydraulic piston pumps and other pertinent vibration sources are given to guide in designing pump vibration isolation mountings. Mount configuration recommendations and design data are provided to simplify the design effort.

MECHANICAL

79-524

Seismic Behavior of Tall Liquid Storage Tanks

A. Niwa

Earthquake Engrg. Research Lab., California Univ., Richmond, CA, Rept. No. UCB/EERC-78/04, 333 pp (Feb 1978)

PB-284 017/1GA

Key Words: Storage tanks, Cylindrical shells, Fluid-filled containers, Earthquake-resistant structures

This report discusses the results of an experimental program in which a scaled model of a ground supported, thin-shell, cylindrical liquid storage tank with height greater than radius was subjected to simulated earthquake excitation. Analytical investigations on out-of-round shell deformation of cylindrical tanks are also presented. This experimental program is the second phase of a research project in which various scaled tank models were tested to assess the applicability of current seismic design practice to ground supported, thin-shell, cylindrical liquid storage tanks.

79-525

Theoretical and Experimental Investigations on Resonant Frequencies and Natural Response of Stators of Electrical Machines

R.S. Girgis

Ph.D. Thesis, The Univ. of Saskatchewan (Canada) (1978)

Key Words: Stators, Resonant frequencies, Natural frequencies

An analysis of a general nature is developed for the determination of values of resonant frequencies and natural response of stators of encased construction. The derived frequency equation is applicable to all modes of vibration and can deliver information about all possible resonant frequencies of a stator. The analysis is based on the three-dimensional theory of elasticity; and it is capable of delivering information about not only the radial vibrations of stators but also about the torsional and axial vibrations. Simplified frequency equations are also derived from the general frequency equation for the special cases of uniform vibrations along the stator circumference and along the stator length.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see No. 523)

79-526

Seismic Design of Gyroscopic Systems

G.J. Kurt Asmis and C.G. Duff

Atomic Energy Control Board, Ottawa, Canada, ASME Paper No. 78-PVP-44

Key Words: Seismic design, Pumps, Nuclear reactor components

The Primary Heat Transport pumps were analyzed for gyroscopic effects during a seismic event. It was found that gyroscopic induced forces could be constrained to acceptable values by providing close fitting, upper lateral seismic restraints.

79-527

Install Compressors for High Availability

C. Jackson

Monsanto Chemical Intermediates Co., Texas City, TX, Hydrocarbon Processing, 57 (11), pp 243-249 (Nov 1978) 16 figs, 3 refs

Key Words: Compressors

Two 9,000 hp centrifugal trains have achieved over 99 percent availability in more than two years of operation. The author describes how they are specified, selected, tested and installed.

79-528

Dynamic Response of Lift Fans Subject to Varying Backpressure

J.M. Durkin and L.H. Luehr

Aviation and Surface Effects Dept., David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD, Rept. No. AERO-1253, DTNSRDC-78/063, 18 pp (July 1978)

AD-A057 292/5GA

Key Words: Fans, Dynamic response

An analytical investigation of the dynamic performance of a centrifugal lift fan was conducted to provide an explanation for the behavior which occurred when the fan was subjected to a varying backpressure. A time-domain digital computer program has been developed which integrates the rate of change of fan flow with a varying backpressure. Good correlation is exhibited between test data and the computer predictions at all frequencies.

79-529

Propulsion Systems Noise Technology

C.E. Feiler

Lewis Res. Center, NASA, Cleveland, OH, In: CTOL Transport Technol., Langley Res. Center, NASA, pp 167-185 (June 1978)

N78-27056

Key Words: Aircraft noise, Engine noise, Fans, Noise reduction

Turbofan engine noise research relevant to conventional aircraft is discussed. In the area of fan noise, static to flight noise differences are discussed and data are presented for two different ways of simulating flight behavior. Experimental results from a swept rotor fan design are presented. Acoustic suppressor research objectives centered around the effect of the wave system generated by the fan stage that is the input to the treatment. A simplifying and unifying parameter, mode cutoff ratio was described.

RAIL

79-530

The Prediction of Aerodynamic and Wheel/Rail Noise Generated by High-Speed Trains

W.F. King, III

Inst. f. Turbulenzforschung, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Berlin, West Germany, Rept. No. DLR-1B-257-77/14, 34 pp (1977)

N78-29877

Key Words: Interaction: rail-wheel, High speed transportation systems, Noise generation

Equations are given for the calculation of both the wheel/rail and aerodynamic noise levels and their predictions are compared to peak noise levels measured during the passage of conventional fast trains, new high-speed trains, and magnetically levitated vehicles.

79-531

Dynamic Response and Optimization of a Railroad Freight Car Under Periodic and Stochastic Excitations

M.A. Samaha

Ph.D. Thesis, Concordia Univ. (Canada) (1978)

Key Words: Railroad cars, Periodic excitation, Stochastic processes, Mathematical models, Suspension systems (vehicles)

Based on an effective nonlinear mathematical model, the dynamic responses of a large capacity railroad freight vehicle are presented when the vehicle is subjected to either a purely periodic or a combination of periodic and random inputs from the tracks. In this investigation, attention is mainly devoted to the response of the vehicle system in its rocking mode which has been identified as n important problem in the railroad industry. The equations of motion of the system are derived using Lagrange's as well as force analysis techniques. Solutions for the transient and steady state rocking responses of the system, when subjected only to a purely periodic track excitation, are obtained using digital integration and analog simulation respectively.

79-532

Analytical Modeling of Guideway Roughness

B. Mudunuri

Ph.D. Thesis, The Univ. of Texas at Arlington, 186 pp (1978)

UM 7821197

Key Words: Guideways, Track roughness, Surface roughness, Mathematical models

The purpose of this study is to relate the power spectral density (PSD) associated with a guideway to various irregularity sources such as terrain irregularities, construction errors, and surface roughness irregularities. The study is aimed at formulation of analytical models for surface roughness type irregularities and constrained terrain irregularities, and to determine the effects of various irregularity sources on ride quality. The first part of the study pertains to model-

ing of short wavelength irregularities associated with a guideway profile resulting from concrete surface roughness, foundation settlement, etc. The second part of the study concerns the derivation of an analytical model for constrained terrain irregularities resulting from terrain roughness. The third part of the study deals with ride comfort analysis.

REACTORS

(Also see Nos. 421, 422, 497, 526)

79-533

Seismic Analysis of the Main Steam System for 600-MWe CANDU Stations

E.B. Deksnis

Canatom Ltd., Montreal, Quebec, Canada, ASME Paper No. 78-PVP-87

Key Words: Nuclear power plants, Piping systems, Seismic response, Mathematical models

The main steam leads for a typical-CANDU 600-MWe nuclear generating station constitute a relatively light and flexible system multiply-connected to several relatively massive and stiff structures that can move independently of one another in response to an earthquake. Conservative bounds on the seismic response of the system have been calculated from dynamic analyses of a mathematical model showing the interaction of piping with the structures.

79-534

Response Spectrum Method with Residual Terms

J.K. Biswas and C.G. Duff

Atomic Energy of Canada Ltd., Mississauga, Ontario, Canada, ASME Paper No. 78-PVP-79

Key Words: Nuclear reactor components, Nuclear power plants, Seismic response, Response spectra

This paper presents a modification of the response spectrum method intended to be used for seismic analysis of systems and components in nuclear power plants. It combines the response from the first few modes, together with residual terms to account for the higher modes. The proposed procedure rectifies this limitation and produces realistic responses at all points. The seismic response of an example tank is worked out using the proposed method. The results are compared with that obtained from the time-history method and found to have reasonable agreement.

79-535

Pump-Induced Acoustic Pressure Distribution in an Annular Cavity Bounded by Rigid Walls

M.K. Au-Yang

The Babcock & Wilcox Co., Lynchburg, VA, ASME Paper No. 78-PVP-69

Key Words: Nuclear reactor components, Sound pressures

This paper describes an analytical method for estimating the coolant pump-induced acoustic pressure distribution in the inlet annulus of a pressurized water reactor. The phenomenon of beating due to slight differences in the pump blade passing frequencies is included in this analysis. An experiment based on a simple laboratory model is carried out to verify the theory, using small loudspeakers to simulate the pumps and air as the fluid medium.

79-536

Nonlinear Effects in Dynamic Analysis and Design of Nuclear Power Plant Components: Research Status and Needs

M. Stoykovich

Burns and Roe, Inc., 185 Crossways Park Dr., Woodbury, NY 11797, Nucl. Engr. Des., 50 (1), pp 93-114 (1978) 9 figs, 4 tables, 78 refs

Key Words: Nuclear power plants, Nuclear reactor components, Nonlinear theories, Interaction: structure-foundation, Seismic response, Computer programs

This paper encompasses nonlinear effects in dynamic analysis and design of nuclear power plant facilities. The history of plasticity as a science is briefly discussed, and nonlinear cases of special interest are described. Approaches to some of the nonlinear problems are presented. These include the nonlinearity due to foundation-structure interaction associated with the base slab uplift during seismic disturbances, the nonlinear base-isolation system for the reduction of earthquake-generated forces and deformations of superstructures, nonlinear systems having restoring-force functions in case of gaps and lift-off conditions, and nonlinearity of viscoelastic systems due to inelastic deformations. Available computer programs information for the solution of various types of nonlinear problems are provided. Advantages and disadvantages of some of the nonlinear and linear analyses are discussed. Comparison of some nonlinear and linear results of analyses are presented.

79-537

Research Needs Associated with Seismic Load on Nuclear Power Plants

J.D. Stevenson

J.D. Stevenson, Consultants, Div. of Arthur G. McKee and Co., Cleveland, OH 44131, Nucl. Engr. Des., 50 (1), pp 63-70 (1978) 2 figs, 4 tables, 7 refs

Key Words: Nuclear power plants, Seismic design

A research program aimed at providing the desired level of seismic resistance of nuclear power plants in a cost-effective manner is proposed. The results of such a research program provide direct measurement of seismic design parameters associated with loadings which closely simulate real strong motion characteristics on major structural and mechanical systems.

79-538
Seismic Design Margins for CANDU-PHW Nuclear Power Plants
C.G. Duff
Atomic Energy of Canada, Ltd., Mississauga, Ontario, Canada, ASME Paper No. 78-PVP-38

Key Words: Nuclear power plants, Seismic design

An adequate design seismic ground motion for a CANDU-PHW nuclear power plant is difficult to determine, especially from limited earthquake records with an absence of active faults. An acceptably low overall probability of exceedence for the design basis earthquake effect on the NPP is postulated, considering DBSGM used, response spectrum and damping chosen, nonlinearities, mass-coupling effects, and reverse strength. Factors of assurance are defined, with examples, showing the conservatism in the design of an NPP for possible earthquakes and the considerable seismic design margins which are available.

79-539
Seismic Effects in Secondary Containments: Research Needs
P. Gergely and R.N. White
Dept. of Structural Engrg., Cornell Univ., Ithaca, NY 14853, Nucl. Engr. Des., 50 (1), pp 41-47 (1978) 2 figs, 15 refs

Key Words: Containment structures, Reinforced concrete, Seismic excitation

The purpose of this paper is to discuss the status of current and projected research on the behavior of nonprestressed secondary containment structures carrying combined pressurization and seismic shear. Ongoing experimental research at Cornell University on specimens carrying combined biaxial tension and static cyclic shear is described. The remainder of the paper treats research needed to better predict the response of containments to seismic effects and to serve as the basis for improved design methods for reinforced concrete containments.

RECIPROCATING MACHINE

79-540
Review of Engine/Airframe/Drive Train Dynamic Interface Development Problems
W.J. Twomey and E.H. Ham
Sikorsky Aircraft Div., United Technologies Corp., Stratford, CT, Rept. No. SER-510003, USARTL-TR-78-13, 129 pp (June 1978)
AD-A057 932/6GA

Key Words: Helicopter engines, Forced vibration, Self-excited vibrations

The coupled interaction between two or more helicopter subsystems has often been the source of vibration problems -- problems often costly and time-consuming to correct because they have not surfaced until the design and development of the individual subsystems is far advanced. This report gives a review of Sikorsky experience with such problems over the past twenty years of developing gas turbine powered helicopters. The problems presented include forced vibration problems (wherein the excitations come from either aerodynamic loads on the main rotor, or mechanical imbalances in the engine/drive train), self-excited vibrations, and a transient response problem.

79-541
Noise Prediction Technology for CTOL Aircraft
J.P. Raney
Langley Res. Center, NASA, Langley Station, VA, In: CTOL Transport Technol., Langley Res. Ctr., NASA, pp 805-818 (1978)
N78-29057

Key Words: Aircraft engines, Noise prediction

The application of a new aircraft noise prediction program to CTOL noise prediction is outlined. Noise prediction is based on semiempirical methods for each of the propulsive system noise sources, such as the fan, the combustor, the turbine, and jet mixing, with noise-critical parameter values derived from the thermodynamic cycle of the engine. Comparisons of measured and predicted noise levels for existing CTOL aircraft indicate an acceptable level of accuracy.

79-542

Low Vibration 20 HP Mini-RPV Engine

G.E. Abercrombie and A.G. Bennett
Bennett Aerotechnical Corp., Auburn, AL, SAE Paper No. 780764, 8 pp, 3 figs, 2 refs

Key Words: Aircraft engines, Engine vibration

The recent advent of small remotely piloted aircraft as tools for both military and civilian missions has set a requirement for reliable, low vibration, compact, reciprocating engines in a power range where such engines have not previously been available. A new twin crank, geared output engine is being developed to satisfy this requirement. The special feature of this engine is its very low vibration. An analysis and the resulting balance criterion that gives this low vibration is presented.

79-543

Influences on Engine Roughness of Otto Engines (Einflüsse auf die Laufunruhe von Ottomotoren)

H.P. Lenz, M. Akhlaghi, and F. Bamer
Institut f. Verbrennungsskraftmaschinen und Kraftfahrwesen der technischen Universität Getreidemarkt 9, A-1060 Wien, Austria, MTZ Motortech. Z., 39 (7/8), pp 313-317 (July/Aug 1978) 9 figs, 12 refs
(In German)

Key Words: Engine roughness, Otto engines

The reasons for the engine roughness of an Otto engine were investigated. The effects of air-fuel ratio, rpm, torque, ignition timing, exhaust back pressure, and turbulence as well as structural parameters of the engine, exhaust-pipe shape, and kind of air-fuel mixture on the engine roughness, were determined.

79-544

A Simple Objective Method for Measuring the Engine Roughness (Ein einfaches und objektives Messverfahren für die Laufunruhe)

V. Bianchi and R. Latsch
Theodor-Heuss-Str. 8, D-7141, Hochdorf, MTZ Motortech. Z., 39 (7/8), pp 303-309 (July/Aug 1978) 7 figs, 24 refs
(In German)

Key Words: Engine roughness, Otto engines

This paper reports on a rather simple method for objectively measuring the engine roughness of the Otto engine. The measured quantity corresponds to changes of the mean angular acceleration between successive crankshaft rotations. It is approximately proportional to changes of mean torque or mean pressure effective during one rotation of the crankshaft. The method consists of measuring the time durations for successive crankshaft rotations by inductive pickup and calculating the roughness by a digital circuit.

ROAD

(See Nos. 406, 407)

ROTORS

79-545

An Investigation of Rotor Noise Generation by Aerodynamic Disturbance

C.E. Whitfield
Dept. of Transport Tech., Loughborough Univ. of Tech., UK, Rept. No. NASA-CR-157571; TT-7711, 135 pp (Sept 1977)
Sponsored by NASA
N78-29870

Key Words: Rotors (machine elements), Noise generation

An open rotor was considered as a process for converting an unsteady velocity inflow into sound radiation. With the aid of crude assumptions, aero-acoustic transfer functions were defined theoretically for both discrete frequency and broad band noise. A study of the validity of these transfer functions yielded results which show good agreement at discrete frequencies though slightly less good for broad band noise.

SHIP

(Also see Nos. 404, 405, 424, 444, 445, 468, 498, 499, 522)

79-546

The Dynamics of Offshore Gravity Platforms: Some Insights Afforded by a Two Degree of Freedom Model

R.E. Taylor and P.E. Duncan
Dept. of Mech. Engrg., University College London, UK, Intl. J. Earthquake Engr. Struc. Dynam., 6 (5), pp 455-472 (Sept/Oct 1978) 10 figs, 1 table, 9 refs

Key Words: Offshore structures, Water waves, Finite element

techniques

This paper presents some findings of an investigation into the dynamic behavior of offshore gravity platforms excited by waves. Results obtained from a finite element model are presented in the form of dynamic magnification factor curves for two structures typical of current concrete platform designs. A simple two degree of freedom model is developed and the equivalent results presented.

79-547

The Dynamics of Offshore Structures Evaluated by Boundary Integral Techniques

R.E. Taylor and J.B. Waite

Dept. of Mech. Engrg., University College London, Torrington Place, London, UK, Intl. J. Numer. Methods Engr., 13 (1), pp 73-92 (1978) 12 figs, 15 refs

Key Words: Offshore structures, Interaction: structure-fluid, Modal analysis

This paper is concerned with the development of transfer functions for the dynamic response of multidegree-of-freedom offshore structures, excited by sinusoidal waves. The problem is formulated in terms of the principal modes of the structure vibrating freely in vacuo. The hydrodynamic analysis is performed through use of a distribution of wave sources on the submerged surface of the structure, which leads to an approximate solution satisfying the boundary condition on the fluid-structure interface at a discrete set of points. Generalized forces are obtained corresponding both to excitation by waves and to the hydrodynamic reactions induced by motions of the structure: the latter are expressed in terms of added mass and damping matrices. Results are given for simple geometries to illustrate the approach.

USEFUL APPLICATION

79-548

Vibratory Ice Protection for Helicopter Rotor Blades

H.E. Lemont and H. Upton

Bell Helicopter Textron, Fort Worth, TX, Rept. No. USAAMRDL-TR-77-29, 174 pp (June 1978)
AD-A057 329/5GA

Key Words: Rotary wings, Helicopter rotors, Deicing systems, Vibratory techniques, Shakers

This report presents the results of a study on vibrational deicing of main and tail rotor blades through higher harmonic shaking of the blades with aerodynamic, mechanical, and hydraulic shakers. Studies were made of various locations for mounting shakers, the forces and frequencies to deice, types of shakers, concept effectiveness, energy requirements, system reliability, system maintainability, weights, costs, aircraft performance penalties, impact on countermeasure methods, effects on aircraft components, and applicability to main and tail rotor blades of both metal and composite construction. Ratings of systems to vibrate blades are compared; electrical control diagrams for shaker mechanisms are presented; and results of a breadboard test are included. A bibliography is presented of reports pertinent to vibrational deicing of rotor blades.

79-549

Pile Driver with High-Frequency Vibrator

G. Einaudi

RIV-SKF, Turin, Ball Bearing J., 197, pp 12-14 (Oct 1978) 3 figs

Key Words: Vibrators (machinery), Pile drivers

An Italian firm manufactures vibrating units, vibrators, for driving and extracting various types of pile. The vibrator is suspended from a mobile crane and acts on the suspended piles by vertical vibrations combined with a constant pressure or tensional force. The vibrations are generated by eight eccentric masses mounted on two shafts which rotate in opposite directions. The speed and length of stroke can be easily changed to suit the size and mass of the piles and the ground conditions. The shafts are supported in spherical roller bearings of the type developed by SKF specially for vibrating applications.

79-550

The Action of the Cello at the Wolf Tone

I.M. Firth

School of Physical Sciences, Univ. of St. Andrews, North Haugh, St. Andrews, Fife, UK, Acustica, 39 (4), pp 252-263 (Mar 1978) 15 figs, 1 table, 10 refs

Key Words: Musical instruments, Violins, Strings, Plates, Coupled response

Detailed observations of the spectral content of the wolf tone show that the non-linear action of the bow-string contact is important in its production. Input mechanical admittance measurements, and interference holographic techniques confirm that the wolf tone is caused by the coupling between the string and the first mode of vibration of the top plate. Input reactance is calculated, and in the region of the wolf, passes through zero three times confirming the treatment of this defect in the cello on the basis of the analogous circuit for the instrument. Other measurements support the introduction of a criterion to determine when an instrument of the violin family will wolf.

AUTHOR INDEX

TECHNICAL NOTES

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J. Appl. Mech., Trans. ASME, 45 (3), pp 685-687 (Sept 1978) 3 figs, 1 table, 9 refs

M.H. Foley
A Minimum Mass Square Plate with Fixed Fundamental Frequency of Free Vibration
AIAA J., 16 (9), pp 1001-1004 (Sept 1978)

M. Pappas
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AIAA J., 16 (9), pp 999-1001 (Sept 1978) 1 table, 11 refs

W.J. Anderson
Whirl-Resistant Sleeve Bearings
Mach. Des., 50 (9), pp 67-68 (Apr 20, 1978)

K. Takahashi and T. Chishaki
Free Vibrations of a Rectangular Plate on Oblique Supports
J. Sound Vib., 60 (2), pp 299-304 (Sept 22, 1978) 4 figs, 1 table, 2 refs

J.H.T. Wu, P.P. Ostrowski, and R.A. Neemeh
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J. Sound Vib., 60 (1), pp 151-156 (Sept 8, 1978) 4 figs, 1 table, 15 refs

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Optimal Allocation of Actuators for Distributed-Parameter Systems
J. Dyn. Syst., Meas. and Control, Trans. ASME, 100 (3), pp 227-228 (Sept 1978) 6 refs

CALENDAR

APRIL 1979

30-May 2 NOISE-CON 79, [INCE] Purdue University, IN *(NOISE-CON 79, 116 Stewart Center, Purdue University, West Lafayette, IN 47907 - Tel (317) 749-2533)*

30-May 2 Environmental Sciences Meeting, [IES] Seattle, WA *(Dr. Amiram Roffman, Energy Impact Assoc., Inc., P.O. Box 1899, Pittsburgh, PA 15230 - Tel. (412) 256-5640)*

30-May 3 1979 Offshore Technology Conference, [ASME] Astrohall, Houston, TX *(ASME Hq.)*

MAY 1979

7-10 Design Engineering Conference & Show, [ASME] McCormick Place, Chicago, IL *(ASME Hq.)*

20-25 Spring Meeting and Exposition, [SESA] San Francisco, CA *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

JUNE 1979

12-16 Acoustical Society of America, Spring Meeting, [ASA] Cambridge, MA *(ASA Hq.)*

18-20 Applied Mechanics, Fluid Engineering and Bioengineering Conference, [ASME-CSME] Niagra Hilton Hotel, Niagra Falls, NY *(ASME Hq.)*

JULY 1979

9-13 5th World Congress on the Theory of Machines and Mechanisms, [ASME] Montreal, Quebec, Canada *(ASME Hq.)*

SEPTEMBER 1979

9-14 Petroleum Mechanical Engineering Conference [ASME] Hyatt Regency, New Orleans, LA *(ASME Hq.)*

10-12 ASME Vibrations Conference, [ASME] St. Louis, MO *(ASME Hq.)*

10-13 Off-Highway Meeting and Exposition, [SAE] MECCA, Milwaukee, WI *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

11-14 INTER-NOISE 79, [INCE] Warsaw, Poland *(INTER-NOISE 79, IPPT PAN, ul. Swietokrzyska 21, 00-049 Warsaw, Poland)*

OCTOBER 1979

7-11 Fall Meeting and Workshops, [SESA] Mason, OH *(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel. (203) 227-0829)*

16-18 50th Shock and Vibration Symposium, Colorado Springs, CO *(H.C. Pusey, Director, The Shock and Vibration Information Center, Code 8404, Naval Research Lab., Washington, D.C. 20375 - Tel (202) 767-3306)*

16-18 Joint Lubrication Conference, [ASLE-ASME] Dayton, OH *(ASME Hq.)*

17-19 Stapp Car Crash Conference [SAE] Hotel del Coronado, San Diego, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

NOVEMBER 1979

4-6 Diesel and Gas Engine Power Technical Conference, San Antonio, TX *(ASME Hq.)*

5-8 Truck Meeting, [SAE] Marriott, Ft. Wayne, IN *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

26-30 Acoustical Society of America, Fall Meeting, [ASA] Salt Lake City, UT *(ASA Hq.)*

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA *(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)*

2-7 Winter Annual Meeting, [ASME] Statler Hilton, New York, NY *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, U.S. Council for TMM, c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab.,
Lexington, MA 02173

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